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Stromatoporoids from the Emsian (Lower Devonian) of Arctic Canada

by

Eric Prosh and Colin W. Stearn

Paleontological Research Institution
1259 Trumansburg Road
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CONTENTS

Page

- Abstract 5
- Introduction 5
- Acknowledgements 5

- Stratigraphy

    - Introduction 6
    - Eids Formation 6
    - Blue Fiord Formation 6
    - Bird Fiord Formation 9
    - Disappointment Bay Formation 9
    - Unnamed Formation 9

- Conodont Biostratigraphy

    - Dehiscens and Gronbergi Zones 9
    - Inversus Zone 10
    - Serotinus Zone 10
    - Undifferentiated Patulus Zone 10

- Stromatoporoid Biostratigraphy and Paleogeography

    - Southwestern Ontario and North-Central United States 11
    - Northern Asia 11
    - Australia and China 11
    - Discussion 13

- Systematic Paleontology

    - Introduction 13

- Systematics
    - Order Actinostromatida
        - Family Actinostromatidae

            - Genus Actinostroma 14
            - Genus Plectostroma 15
            - Genus Aculatostroma 16

    - Order Clathrodictyida
        - Family Clathrodictyidae

            - Genus Clathrodictyon 17
            - Genus Gerronostroma 18
            - Genus Petridiostroma 19
            - Genus Atelodictyon 20

        - Family Tienodictyidae

            - Genus Anostylostroma 21
            - Genus Pseudoactinodictyon 22
            - Genus Schistodictyon 23

    - Order Stromatoporellida
        - Family Stictostromatidae

            - Genus Stictostroma 24
            - Genus Stromatoporella 26
            - Genus Clathrocoilona 27

        - Family Hermatostromatidae

            - Genus Trupetostroma 30

    - Order Stromatoporida
        - Family Stromatoporidae

            - Genus Stromatopora 31
            - Genus Ferestromatopora 32
            - Genus Glyptostromoides 33

        - Family Syringostomellidae

            - Genus Syringostromella 34
            - Genus Salairella 34

    - Order Syringostromatida
        - Family Syringostromatidae

            - Genus Atopostroma 35
            - Genus Habrostroma 36
            - Genus Parallelopora 37
- Appendix 1. Collection Localities 38
- Appendix 2. Catalogue of Type Numbers and Locations 39
- Appendix 3. Collecting locations and stratigraphic positions 40
- References cited 42
- Plates 46
- Index 64

LIST OF ILLUSTRATIONS

Text-figure Page

1. Position of collecting localities in Canadian arctic islands. 7
2. Correlation chart of formations from which stromatoporoids were collected. 8
3. Stratigraphic ranges of Lower and lower Middle Devonian stromatoporoids. 12

LIST OF TABLES

Table Page

1. Comparative measurements of *Stictostroma gorriense* Stearn. 25

STROMATOPOROIDS FROM THE EMSIAN (LOWER DEVONIAN) OF ARCTIC CANADA

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McGill University, Montreal, Canada

ABSTRACT

Early Devonian limestones of Ellesmere, Bathurst, and smaller islands between them in the Canadian Arctic Archipelago contain a diverse fauna of stromatoporoid sponges. This fauna provides the best evidence in North America of the early recovery phase of this reef-building group from a diversity low at the Silurian/Devonian boundary, a recovery that lead to its diversity peak in Givetian time. Stromatoporoids from the lower member of the Blue Fiord Formation locally form large reefal masses. Well preserved stromatoporoids also occur less abundantly: 1. in the top of the underlying Eids Formation, 2. in the upper member of the Blue Fiord Formation, 3. in the Disappointment Bay Formation, which is correlative of the upper Blue Fiord, and, 4. in the overlying Bird Fiord Formation, and a correlative unnamed formation, both of which span the Lower/Middle Devonian boundary. The stratigraphic distribution of these stromatoporoids can be accurately determined according to conodont biostratigraphy as spanning the *dehiscens* to *partitus* (Emsian to basal Eifelian) conodont zones. Common occurrences of *Stromatoporella perannulata, Stictostroma gorriense, Habrostroma proxilaminatum,* and *Parallelopora campbelli* in the arctic fauna and southern Ontario and the adjacent United States, indicate that the Detroit River Group is of similar Emsian age, and that the Eastern Americas realm was open to migration from the Arctic. Similarity of species with the Emsian faunas of Russia, Australia and China suggests the cosmopolitan and equatorial distribution of stromatoporoids in Emsian time and opens possibilities for using the group in correlation. The fauna is therefore important in establishing both the evolution of the order and also its geographic distribution in Early Devonian time.

Twenty-five species (assigned to 22 genera) are described. The species concept used is a broad one and the range of variation in each taxon is documented. New species described are: *Gerronostroma septentrionalis, Anostylostroma anfractum, Pseudoactinodictyon conglutinatum, Stictostroma? nunavutense, Clathrocoilona vexata, Stromatopora hensoni.* The morphologic limits of the following genera are considered in the description of species: *Plectostroma, Aculatostroma* and *Atelodictyon, Clathrocoilona, Salairella* and *Syringostromella.* The range of *Trupetostroma* is extended downward into Emsian strata.

INTRODUCTION

Rocks of earliest Devonian age cover a relatively small area of the North American platform because this was a time of worldwide regression at the close of the Tippecanoe sequence. Reef faunas of this age are restricted in their distribution and of low diversity. In North America the Kaskaskia transgression appears to have started in the north and, spreading southward in shallow seas across the platform, brought with it a reef-building fauna rich in stromatoporoids. The first reef complexes of regional extent built in this sea were in the area that is now the Canadian Arctic Archipelago and are contained within the Blue Fiord Formation. This study describes the elements of this resurgent reef fauna. In eastern and arctic North America the growth of the reef fauna in subsequent Middle and Late Devonian time was progressively inhibited by siliciclastic input, but in the Western Canada Sedimentary Basin reefs thrived through the middle part of the period and their growth culminated in giant Frasnian reef complexes.

This study expands and refines earlier work by Stearn (1983) on the Emsian stromatoporoids of southern Ellesmere Island. Stearn described a fauna collected from the lower 100 m (lower Emsian, *dehiscens* Zone) of the Blue Fiord Formation in the type area between Eids and Sör Fiords (Text-fig. 1A). Of the 11 species described by Stearn (1983), eight are recognized in this study: *Clathrodictyon ellesmerense* Stearn, 1983, *Gerronostroma septentrionalis* n. sp., *Clathrocoilona vexata* n. sp., *Stromatopora polaris,* Stearn, 1983, *Stromatopora* cf. *S. hupschii* (Bargatzky, 1881), *Glyptostromoides simplex* (Yang and Dong, 1979), *Salairella prima* Khromych, 1971, and *Atopostroma distans* (Ripper, 1937b). The three species that do not occur in the collections studied here, which were made by Gary Smith and Eric Prosh, are all represented in Stearn's (1983) collections by single specimens. These include *Gerronostroma* cf. *G. immemoratum* Bogoyavlenskaya, 1977, *Amphipora* sp., and *Labechia* sp. No amphiporids were found in these larger collections. The single poorly preserved specimen referred to *Labechia* sp. has been tentatively identified as *Syringodictyon tuberculatum* (Nicholson) by St. Jean (1986).

ACKNOWLEDGEMENTS

We are grateful to Gary P. Smith who, in the preparation of his doctoral dissertation (Smith, 1984), collected most of the specimens on which this study is based. The field work of Smith (in 1978, 1979, and 1980) and of Prosh (in 1983 and 1992) was made possible by the logistic support of the Polar Continental Shelf Project of Natural Resources Canada. Smith's field work was funded by Natural Resources Canada, the Natural Science and Engineering Council, and the McGill Centre for Northern Studies and Research. The research of Eric Prosh and Colin Stearn is funded by grants from the Natural Sciences and Engineering Research Council, Canada to Stearn. For critical comments that have improved the manuscript we are grateful to Barry Webby, Carl Stock, and Warren Allmon.

STRATIGRAPHY

INTRODUCTION

The Emsian and basal Eifelian stromatoporoids described in this study were collected from the Eids, Blue Fiord, Disappointment Bay, Bird Fiord, and an unnamed formation. The great majority of specimens were collected by Gary Smith and Colin Stearn from the Blue Fiord Formation (lower to upper Emsian) of Ellesmere Island. Most of the Blue Fiord specimens were collected along a broad outcrop belt extending from Blue and Bird fiords in the west to Sör Fiord in the east (Text-fig. 1A). Because this outcrop belt includes the type section of the Blue Fiord Formation, localities within the belt are referred to in the text as within the "type area" or in the "vicinity of the type section". Supplementary collections from the Eids and Bird Fiord formations, which respectively underlie and overlie the Blue Fiord Formation (Text-fig. 2), were also included in the study. Collections of Smith and Stearn from the Blue Fiord Formation northeast of the type area in the vicinity of Vendom Fiord (Text-fig. 1B) and by Smith from southwestern Ellesmere Island at Muskox and Goose Fiords (Text-fig. 1C) were also studied. The location of the collections studied and the stratigraphic sections measured by Smith (1984) are plotted on Text-figure 1 and listed by latitude and longitude in Appendix 1. The geology of this southern coast of Ellesmere Island has been described recently by Mayr *et al.* (1994).

The Disappointment Bay Formation of Bathurst, Cornwallis, and adjacent islands is a correlative of the middle-to-upper Blue Fiord Formation of Ellesmere Island (Text-fig. 2). Small collections from the Disappointment Bay Formation on Truro Island (Text-fig. 1, loc. 34) made by Eric Prosh in 1983 and 1992 and from Lowther Island (Text-fig. 1, loc. 33) in 1983 are also described here.

On Bathurst Island and neighbouring islands, the uppermost Emsian and Eifelian are represented by an unnamed limestone that has been referred to incorrectly as the Blue Fiord Formation. Stromatoporoids were collected from this unnamed formation on Bathurst Island by Smith and on nearby Truro Island by Prosh.

EIDS FORMATION

The Eids Formation (Text-fig. 2) consists mostly of calcareous siltstone and shale, with less limestone, siltstone and sandstone. It conformably underlies the Blue Fiord Formation in southern and central Ellesmere Island (Trettin, 1978). West of Sör Fiord it reaches a thickness of 767 m (Uyeno, 1990). With the exception of the uppermost beds transitional to the Blue Fiord Formation, the Eids Formation is poorly fossiliferous. It ranges in age from Lochkovian to earliest Emsian. Silty carbonates on Bathurst and adjacent islands assigned by Kerr (1974) to the Eids Formation are much younger than the Eids on Ellesmere Island.

Stromatoporoid specimens identified in this study as from the Eids Formation come from the upper 100 m in the Blue and Sör fiords areas of Ellesmere Island. In these areas the upper Eids consists of dark gray, calcareous siltstone and mudstone with interbeds of fossiliferous lime wackestone and isolated bioherms (Smith, 1984).

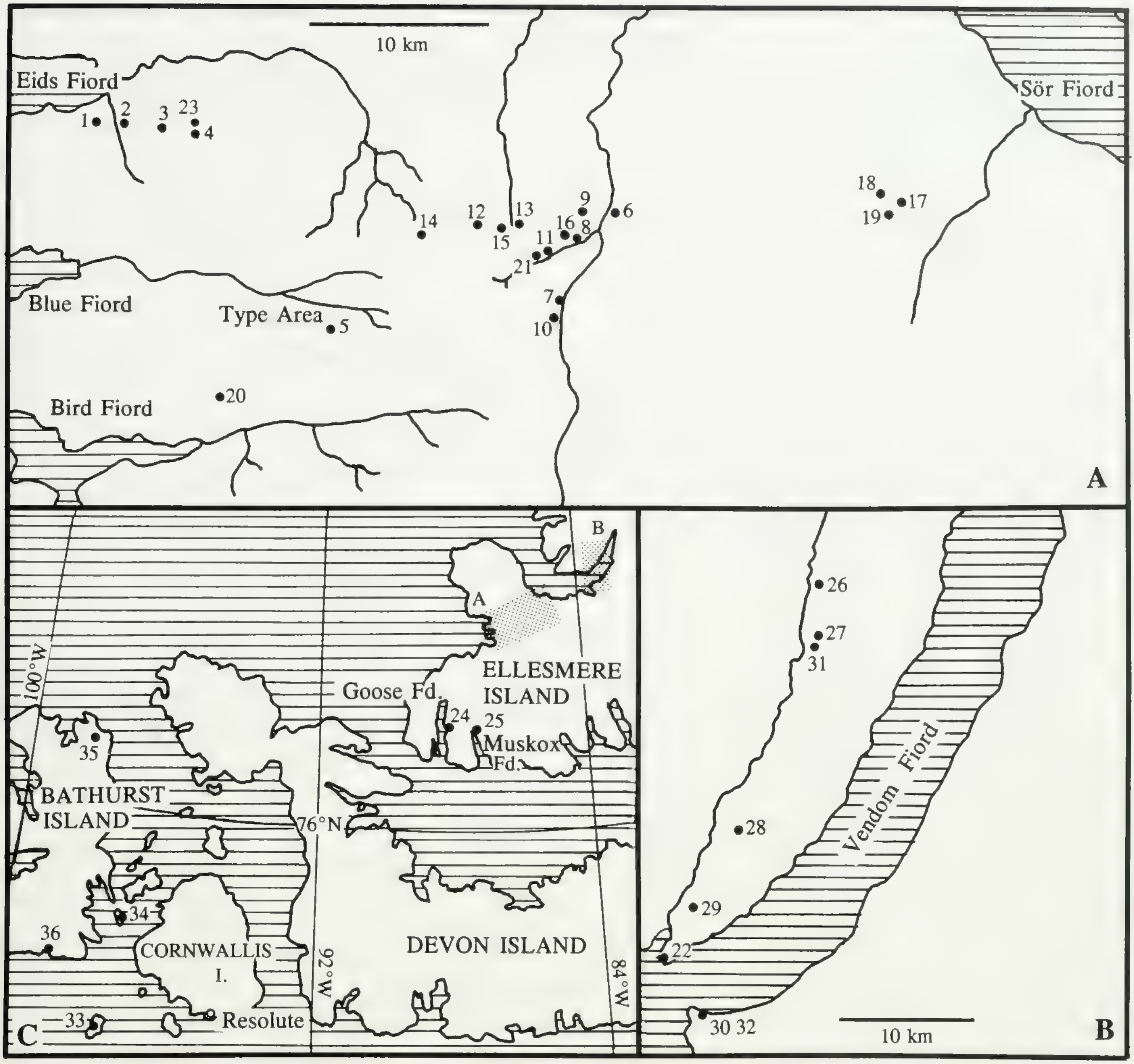
BLUE FIORD FORMATION

The Blue Fiord Formation is an important and widely distributed cliff-forming unit in the arctic islands. The best exposed sections occur on southern Ellesmere Island and adjacent islands. The type section was designated by McLaren (1963) between Blue Fiord and Eids Fiord (Text-fig. 1A). The typical Blue Fiord is predominantly a dark fossiliferous limestone spanning most of the Emsian Stage (Smith, 1984).

The Blue Fiord Formation has been recorded from the arctic islands west of Ellesmere Island (Thorsteinsson and Tozer, 1962) and from the subsurface (Mayr, 1980) in the Bent Horn oilfield (a short distance west of the northwest tip of Bathurst Island and just off Text-fig. 1C). Much of what has been referred to the Blue Fiord Formation in the western arctic islands, however, is of Eifelian age, and should ultimately be referred to a new, as yet undescribed formation (see unnamed Formation below).

Studies of Blue Fiord macrofossils include those of Brice (1982) and Jones and Boucot (1983) on brachiopods, Ormiston (1967) on trilobites, and Pedder (1982, 1983) on corals.

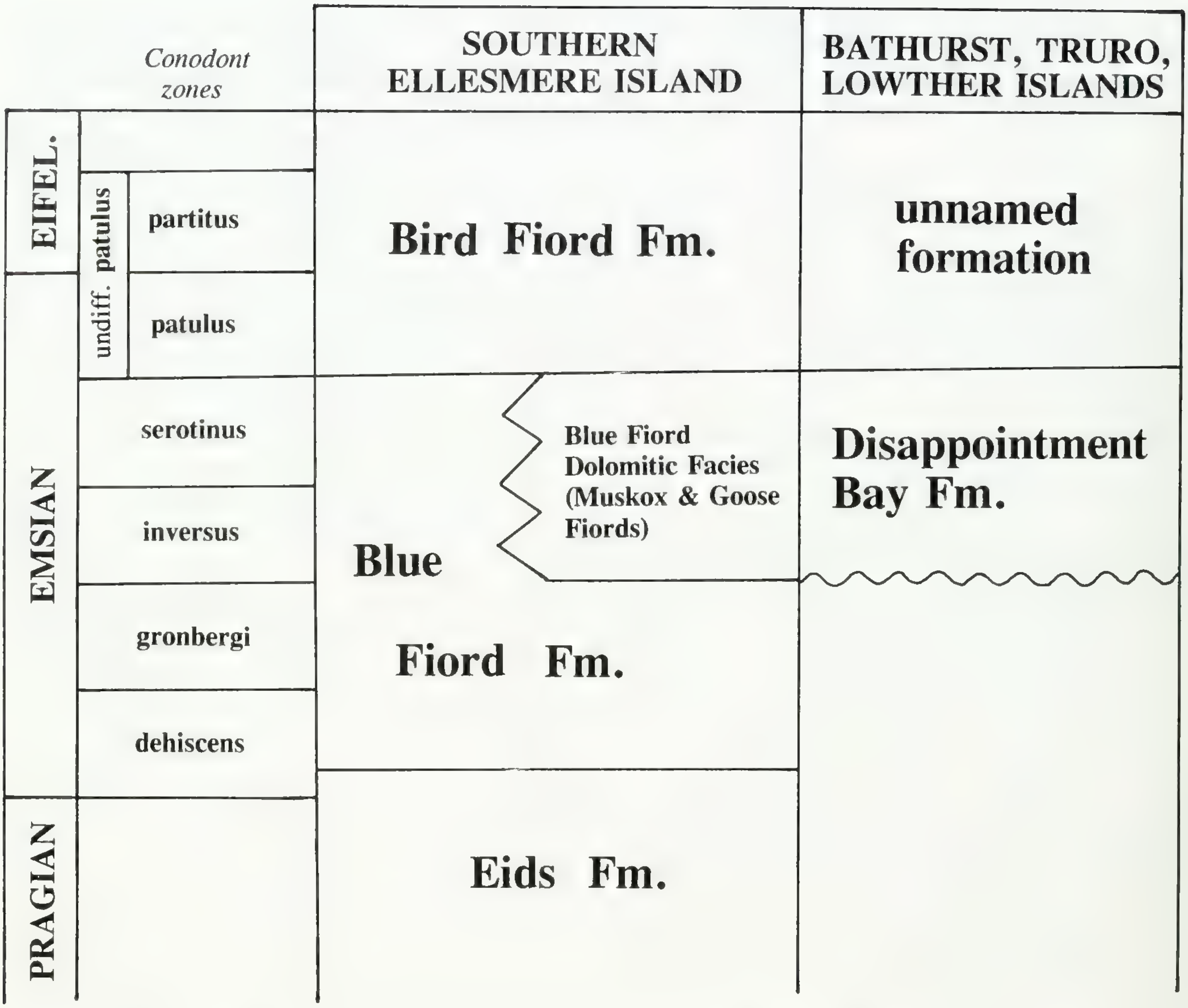
In the type area of the Blue Fiord Formation, McLaren (1963) recognized two members: a lower limestone and shale member and an upper brown limestone member. The lower member is about 700 m thick


10 km
Eids Fiord
1
2
3
23
4
Sör Fiord
18
17
19
9
6
14
12
13
15
16
8
11
21
Blue Fiord
Type Area
5
7
10
20
Bird Fiord
A
B
A
ELLESMERE ISLAND
Goose Fd.
24
25
Muskox Fd.
100°W
35
BATHURST ISLAND
76°N
34
36
CORNWALLIS I.
92°W
DEVON ISLAND
84°W
33
Resolute
C
26
27
31
Vendom Fiord
28
29
22
30 32
10 km
B

Text-figure 1.—Position of collecting localities in Canadian arctic islands. Precise positions by longitude and latitude for the numbered localities are given in Appendix 1. A. Blue Fiord-Sör Fiord area. B. Vendom Fiord area. C. Localities outside A and B. The stippled boxes show the positions of maps A and B. Truro Island—34, Lowther Island—33.

(689 m; Uyeno, 1990) and consists of brownish gray to brown nodular limestones and lesser interbedded gray calcareous mudstones and shales (McLaren, 1963). The lower member is cliff-forming, abundantly fossiliferous and contains large stromatoporoid-bearing bioherms. Smith (1984), and Smith and Stearn (1982, 1987a) recognized a variety of lithologic units within the lower member: interbedded lime mudstone and shale, argillaceous fossiliferous wackestone, skeletal grainstone to packstone, coral-stromatoporoid boundstone. The upper brown limestone member is 572 m thick in a section near the type section (Uyeno, 1990) and consists of brown and brownish gray, bioclastic, coarse-grained limestone but contains relatively few fossils.

On the west side of Vendom Fiord (Text-fig. 1B) the Blue Fiord Formation consists of about 1200 m of limestone and minor siltstone. Two informal units are


Conodont zones
SOUTHERN ELLESMERE ISLAND
BATHURST, TRURO, LOWTHER ISLANDS
EIFEL.
EMSIAN
PRAGIAN
undiff. patulus
partitus
patulus
serotinus
inversus
gronbergi
dehiscens
Bird Fiord Fm.
unnamed formation
Blue Fiord Dolomitic Facies (Muskox & Goose Fiords)
Disappointment Bay Fm.
Blue Fiord Fm.
Eids Fm.

Text-figure 2.—Correlation chart of formations from which stromatoporoids were collected.

recognized: 1) a lower carbonate member about 900 m thick consisting of gray limestone with dolostone interbeds and dark grayish-brown limestone, and 2) an upper siltstone-carbonate member of greenish siltstones, calcareous siltstones and limestone interbeds overlain by a resistant grayish-yellow limestone and dolostone (Uyeno, 1990). The upper siltstone-carbonate member is the same unit provisionally assigned to the Bird Fiord Formation by Jones (1982).

To the north and east of the type area as far as central Ellesmere Island, Blue Fiord lithologies represent progressively more restricted depositional environments (Kerr, 1976; Trettin, 1978). On southernmost Ellesmere Island at Goose Fiord and adjacent Muskox Fiord, the formation is mostly dolomitic and deposition began later than in the type area, in Late Emsian time (Text-fig. 2)(Mayr *et al.*, 1994). This platformal dolomitic facies also occurs on adjacent parts of Devon Island (Kerr, 1977; Prosh *et al.*, 1988). Lithologically the dolomitic Blue Fiord consists of vuggy dolostone, vuggy lime mudstone, and dark fossiliferous lime wackestones and dolowackestones (Smith and Stearn, 1987b). The dolomitic Blue Fiord records a period of late Emsian transgression and platform inundation; it is approximately correlative with the upper member of the type Blue Fiord. Smith and Stearn (1987b) proposed that the dolomitic facies of the Blue Fiord be assigned to the Disappointment Bay Formation, but the term Blue Fiord is retained for these beds here (Prosh *et al.*, 1988).

BIRD FIORD FORMATION

The Bird Fiord Formation overlies the Blue Fiord Formation conformably, and reflects in its lithology a transition to siliciclastic depositional conditions. It is widely distributed on southwestern Ellesmere Island, northwestern Devon Island and the Bathurst Island group (Goodbody, 1989). It ranges in age from latest Emsian to Eifelian. In the type area on Ellesmere Island it is over 800 m thick (Goodbody, 1989).

A few stromatoporoid specimens were studied from the lower Bird Fiord Formation in the type area on the north side of Bird Fiord. These beds (the Norwegian Bay Member of Goodbody, 1989) consist of bioclastic sandy limestone and calcareous siltstone with minor shale and argillaceous siltstone.

DISAPPOINTMENT BAY FORMATION

This late Emsian formation (Text-fig. 2) has been studied on Cornwallis Island, eastern Bathurst Island, and intervening smaller islands (Kerr, 1974; Thorsteinsson, 1980, 1986). It is mostly dolostone but locally on Bathurst, Truro, and Lowther islands (Text-fig. 1C), rare limestones (low in the formation) are abundantly fossiliferous.

On Truro Island, the Disappointment Bay Formation consists mostly of light-colored, massive, vuggy, microcrystalline dolostone with subordinate laminated dolostone. It is about 200 m thick (Kerr, 1974). On the northeastern tip near the base of the formation, small reef knolls occur. Kerr (1974) and Thorsteinsson (1986) do not indicate this occurrence on their maps. Stromatoporoid specimens were collected from these reef knolls of dark gray-brown, bituminous, fossiliferous packstone. The small knolls are lithologically similar to coeval larger knolls in the Disappointment Bay Formation on Lowther Island (Thorsteinsson, 1980; Prosh, 1989).

UNNAMED FORMATION

An unnamed unit consisting of limestone and minor dolostone and shale conformably overlies the Disappointment Bay Formation on eastern Bathurst, Cornwallis, and intervening small islands (map unit D-1 of Thorsteinsson, 1986). On Bathurst Island it incorporates most or all of what Kerr (1974) erroneously referred to as the Blue Fiord Formation. Kerr's Bathurst Island "Eids Formation", a distal equivalent of his "Blue Fiord Formation", probably also belongs to the unnamed formation (Thorsteinsson, pers. comm., 1992). The unnamed formation spans the Emsian–Eifelian boundary and is 20–100 m thick (Thorsteinsson, 1986) (Text-fig. 2).

Stromatoporoids used in this study were collected from the lower 100 m of the formation at the easternmost end of Bathurst Island and at Dyke Ackland Bay on the southern coast (Text-fig. 1C, locs. 35, 36). On the western coast of Truro Island (Text-fig. 1C, loc. 34) 4–6 m of the unnamed formation contain a coral-stromatoporoid biostrome locally up to 6 m thick. Stromatoporoids from this biostrome are included in this study.

CONODONT BIOSTRATIGRAPHY

In this study we have been able to relate the stratigraphic ranges of stromatoporoids directly to an established conodont zonation, in other words to the standard Emsian zonal scale (Text-fig. 2). This is in great measure due to the excellent work of Uyeno (1990) who has documented the conodont zonation of the Devonian of southern Ellesmere Island. Many of the stromatoporoids used in this study come from localities identical or closely comparable to those of Uyeno and Klapper (1980) and Uyeno (1990). In the following paragraphs, the biostratigraphic framework is outlined and the stratigraphic intervals bearing stromatoporoids are placed in the standard conodont zonation.

DEHISCENS AND *GRONBERGI* ZONES

These zones comprise the lower Emsian. In a measured section in the type area of the Blue Fiord Formation, Uyeno and Klapper (1980) and Uyeno (1990) have recognized the *dehiscens* Zone in the lower 267 m of the lower member. The *gronbergi* Zone is recognized by the first appearance of *Polygnathus* aff. *P. perbonus* as *Polygnathus gronbergi* itself does not occur. In this section the *gronbergi* Zone is recognized in the 267 to 393 m interval of the lower member. Because *P. gronbergi* is absent and the *gronbergi* Zone here spans a relatively small stratigraphic interval, we commonly combine the *dehiscens* and *gronbergi* zones in dating. Consequently, stromatoporoids occurring exclusively from the lower 250 m or so of the formation of the type area Blue Fiord are assigned to the *dehiscens* Zone. Stromatoporoids occurring through the lower member up to about 400 m are assigned to a combined *dehiscens/gronbergi* Zone.

In the Vendom Fiord area, conodont zones in the lower member of the Blue Fiord Formation cannot be as precisely placed as in the type area (Uyeno, 1990). Conodonts and macrofossils associated with the *dehiscens* Zone occur low in the formation. The *dehiscens* and *gronbergi* zones probably occur in the lower two thirds of the lower member here: *P. inversus* first appears high in the lower member. Stromatoporoids from low in the lower member at Vendom Fiord are assigned to the *dehiscens* Zone; those from low to medial parts of the member to the combined *dehiscens/gronbergi* Zone.

In the Sör Fiord area, Uyeno and Klapper (1980) have identified *P. dehiscens* from the uppermost beds of the Eids Formation. The full extent of its occurrence in this formation is not known, but presumably the base of the Emsian is near the top of the formation. Stromatoporoids from the highest beds of the Eids Formation are assigned to the *dehiscens* Zone; those 50 or more meters below the top of the Eids are possibily uppermost Pragian.

INVERSUS ZONE

This zone is widely and readily recognized in arctic Devonian strata. In the Blue Fiord type area, the *inversus* Zone spans the interval from 393 to 1104 m, the upper half of the lower member and much of the upper member (Uyeno, 1990). At Vendom Fiord the *inversus* Zone ranges from the upper part of the lower member through much of the upper member of the Blue Fiord Formation. In both the type and Vendom Fiord areas, in the upper member of the formation, stromatoporoids are relatively rare and are assigned to a combined *inversus/serotinus* Zone.

On southernmost Ellesmere Island, the dolomitic facies of the Blue Fiord Formation ranges in age from the *inversus* to *serotinus* zones (Smith and Stearn, 1987b). Stromatoporoids from this dolomitic facies from Muskox Fiord and Goose Fiord areas, are all from low in the formation and assignable to the *inversus* Zone.

Although the lower Disappointment Bay Formation is firmly dated as *inversus* Zone, the upper part is dolomitic and evaporitic and unfossiliferous. Stratigraphic relations suggest that the formation spans the full *serotinus* Zone as well. Stromatoporoids from the lower Disappointment Bay Formation at Truro and Lowther islands occur within the *inversus* Zone (Thorsteinsson, 1980).

SEROTINUS ZONE

In a section 2.5 km east of the type section of the Blue Fiord Formation the *serotinus* Zone is identified in the interval of the upper member from 1104 m to the top of the formation at about 1260 m (Uyeno, 1990). At Vendom Fiord the zone is recognized in the uppermost part of the Blue Fiord upper member. Although *P. serotinus* itself ranges up into the overlying Bird Fiord Formation, the overall faunal and stratigraphic context suggests that the zone ends at the top of the Blue Fiord Formation in the type area (Uyeno, 1990).

UNDIFFERENTIATED *PATULUS* ZONE

The Emsian–Eifelian boundary is placed at the boundary between the *patulus* and *partitus* zones (Ziegler and Klapper, 1985). Because in the arctic islands the nominal conodonts of neither of these zones has been recognized, this interval must be dated by other fossil occurrences and by stratigraphic context. For dating stromatoporoid occurrences, we treat this interval as the undifferentiated *patulus* Zone (*i.e.,* combined *patulus* and *partitus* zones). Two formations that contain stromatoporoids span this interval: 1) the lower Bird Fiord Formation of Ellesmere Island, and 2) the lower unnamed formation of Truro and eastern Bathurst Islands.

1) Uyeno (1990) placed the Lower–Middle Devonian boundary at or near the base of the Bird Fiord Formation at its type section. Although diagnostic conodonts are absent, brachiopods and corals from higher in the formation suggest Eifelian and Dalejan (late Emsian) ages (Uyeno, 1990). Goodbody (1989) considerd the basal Bird Fiord to be included in the *patulus* Zone. On this basis we date the stromatoporoids that have been collected from the lower Bird Fiord Formation on Ellesmere Island as coming from the undifferentiated *patulus* Zone.

2) Similar uncertainty in dating applies to the unnamed formation of Truro and Bathurst islands. Kerr (1974) considered the lower unnamed formation (Blue Fiord of Kerr) as Eifelian and possibly latest Emsian in age, largely on the basis of its trilobite fauna. A sample of the unnamed formation analyzed for conodonts by T. T. Uyeno yielded no specimens (Uyeno, pers. comm. 1993; GSC internal report 02-TTU-93).

The age of the unit underlying the unnamed formation is important in estimating the age of the formation. In the area of Cornwallis, Truro and Lowther islands, the Disappointment Bay Formation is dated as *inversus* Zone (Thorsteinsson, 1980) on the basis of diagnostic conodonts recovered from rare limestones low in the formation. The upper Disappointment Bay Formation is assumed to span most, or all, of the *serotinus* Zone and the transition to limestones of the unnamed formation is assumed to begin at about the *patulus* Zone. This conclusion is based on correlation of the transition from Blue Fiord to Bird Fiord formations on Ellesmere Island with that between the Disappointment Bay and unamed formation in the Cornwallis Island area suggested by Thorsteinsson (1986).

Stromatoporoids collected from the unnamed formation come from the base at Truro Island and from the lower 100 m of the formation on eastern Bathurst Island. In both areas they are probably of latest Emsian age (*patulus* Zone). Due to the uncertain dating of this interval, however, they are assigned to the undifferentiated *patulus* Zone.

The stromatoporoid fauna offers some clue as to the age of the lower unnamed formation (Text-fig. 3). Some faunal turnover is apparent between the the Blue Fiord (*dehiscens* to *serotinus* zones) and the unnamed formation (undifferentiated *patulus* Zone) collections, but a significant number of species range through both assemblages. This suggests that no hiatus separates the Blue Fiord and younger assemblages.

STROMATOPOROID BIOSTRATIGRAPHY AND PALEOGEOGRAPHY

In this study stromatoporoid ranges have been precisely dated, allowing meaningful comparisons of the arctic Emsian fauna to coeval faunas world-wide and the assessment of the biostratigraphic usefulness of stromatoporoids (Text-fig. 3). Of the 25 taxa described in this study, 13 have been recorded from other places and supply information on the distribution of stromatoporoid faunas in Emsian time. These regions are, in decreasing order of similarity and importance: 1) north-central United States and southwestern Ontario, 2) Russian Asia, 3) southeastern Australia, and 4) China. When localities sharing species with the Arctic Emsian fauna are plotted on a reconstruction of the continental configurations of Early Devonian time, such as that of Scotese (Stock, 1990), they are distributed throughout the tropical world of that time. On a broad scale the Emsian stromatoporoid fauna appears to have been a cosmopolitan one and stromatoporoids must have propagated along the tropics with little impediment.

SOUTHWESTERN ONTARIO AND NORTH-CENTRAL UNITED STATES

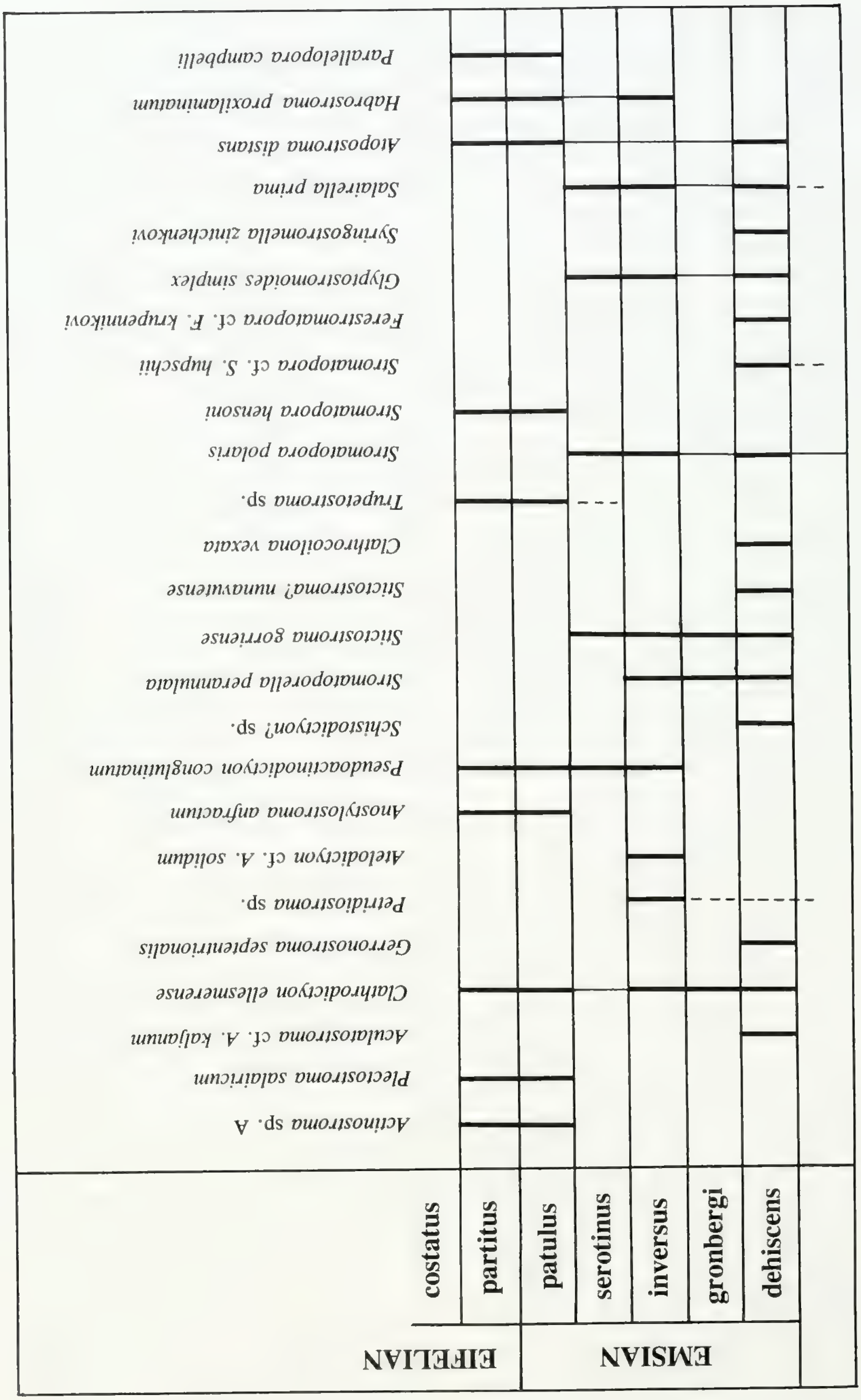
Four species known only from this mid-continent region, *Stromatoporella perannulata* Galloway and St. Jean, *Stictostroma gorriense* Stearn (=*mamilliferum* Galloway and St. Jean), *Habrostroma proxilaminatum* (Fagerstrom), and *Parallelopora campbelli* Galloway and St. Jean, have been identified in the arctic Emsian fauna. In addition the arctic *Trupetostroma* sp. and *Pseudoactinodictyon conglutinatum* n. sp. are closely comparable to species from southwestern Ontario (Fagerstrom, 1982). This sharing of species has led Prosh and Stearn (1993) to conclude that the Detroit River Group of southern Ontario is entirely of Emsian age. The reasoning that led to the reinterpretation of the correlation of the Detroit River Group is presented elsewhere (Prosh and Stearn, 1993). The identity of species indicates a dispersal of stromatoporoids along an open seaway connection from the Arctic to the mid-continent during *serotinus* Zone time and perhaps as early as during *inversus* Zone time. That the isolation of the Eastern Americas Realm of Oliver (1976b) based on the distribution of rugose corals (Oliver, 1976a; Oliver and Pedder, 1989) and on stromatoporoids (Stock, 1990) was not as absolute as proposed, has already been suggested by Stearn (1983) and is fully supported by this study. The migration route of stromatoporoids across the present site of Hudson Bay may have been closed to rugose corals by ecological barriers. Evidence is accumulating that environments favorable to stromatoporoids and tabulate corals may have been different from those that favored rugose corals (Mallamo *et al.*, 1993). In any case, the paleogeographic reconstructions of Oliver (1976b), Oliver and Pedder (1989), and Witzke (1990) need to be modified to show an open seaway connection between the Arctic Islands and southwestern Ontario.

NORTHERN ASIA

Plectostroma salairicum (Yavorsky) is known in the Arctic from the unnamed formation (Bathurst Island) and from the Kuznetsk Basin of central Russia (Yavorsky, 1930). The age of both these occurrences is virtually identical, at or near the Emsian-Eifelian boundary. *Aculatostroma* cf. *A. kaljanum* (Bogoyavlenskaya) from the lower Emsian part of the Blue Fiord Formation is known (as *Coenellostroma kaljanum* Bogoyavlenskaya) from the eastern slope of the northern Urals and from lower Emsian strata (Bogoyavlenskaya, 1977; Khodalevich *et al.*, 1982). *Gerronostroma* cf. *G. immemoratum* Bogoyavlenskaya, described by Stearn (1983) from the lower Blue Fiord, also was originally described from this fauna. *Atelodictyon* cf. *A. solidum* Khromych (Blue Fiord Formation, *inversus* Zone) was previously recorded (*A. cylindricum solidum* Khromych) from probable mid-to-late Emsian rocks in northeastern Siberia (Khromych, 1971, 1976). Two other arctic species are also recorded from Russia, but appear to be longer ranging. *Syringostromella zintchenkovi* Khalfina occurs in the upper Lochkovian of the Salair, southcentral Russia (Khalfina, 1961) and *Salairella prima* Khromych from probable Pragian rocks in Severo-Vostok, eastern Siberia (Khromych, 1971, 1976). Both of these species also occur in Australia (see below).

AUSTRALIA AND CHINA

Affinities with the Early Devonian faunas of Victoria (Webby *et al.*, 1993) are indicated by the cosmopolitan species *Syringostromella zintchenkovi* Khalfina, *Stromatopora polaris* Stearn, *Atopostroma distans* (Ripper) and *Salairella prima* Khromych. The arctic Emsian fauna shares 7 genera in common with the 11 taxa described by Webby and Zhen (1993) from the Jesse Limestone of New South Wales. At the specific level *Atopostroma distans* and *Salairella prima* occur in both faunas.



Text-figure 3.—Stratigraphic ranges of Lower and lower Middle Devonian stromatoporoids.

The species *Glyptostromoides simplex* (Yang and Dong) is common to the Emsian of the south China continental plate and the arctic Emsian.

DISCUSSION

This synthesis demonstrates that the stromatoporoids have more biostratigraphic value than has been conventionally attributed to them. A prerequisite for the confident use of these fossils in correlation is that dating of occurrences be precise as in this study of the Emsian of the Arctic. Such dating has generally been lacking in classical studies of stromatoporoid systematics in part because rigorous, internationally accepted standards of dating postdate many of these studies. Stromatoporoids have been conventionally regarded as poor candidates for correlation in the belief that the species are too long ranging and too provincial. Conservative taxonomic philosophies, species defined without clear appraisal of range of variation within skeletons or between specimens, and oversplitting of taxa have made recognition of species across national boundaries difficult. The recognition of the world-wide distribution and narrow stratigraphic range of some species in this study demonstrates that the biostratigraphic and paleogeographic value of this group is potentially great. Some genera in which taxonomic problems at the species level persist, such as *Stromatopora* and *Clathrocoilona,* may be poor candidates for correlative purposes, but other genera, such as *Stictostroma* and *Stromatoporella,* where species are better defined, have great biostratigraphic potential.

The chronologic development of stromatoporoids in Early Devonian time has recently been reviewed by Webby *et al.* (1993). The diversity and wide distribution of the Emsian world fauna shows that the rapid diversification of stromatoporoids to form the better-known reef complexes of Middle and Late Devonian time was well underway in Early Devonian time.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

Stromatoporoids are an extinct class of sponges allied to the extant coralline sponges (Stearn, 1972, 1975a). Little can be gleaned from the distant stromatoporoid-sponge relationship, however, to assist in setting limits to extinct stromatoporoid species. Most of the classical systematic studies of stromatoporoids (pre-1960s) employed a species concept that by current standards would be considered narrow. Sample suites were often limited in size and geographic scope, and as a result new species were plentiful. Many of these have since been combined in synonymy. In more recent years, larger samplings have been collected, and more attention has been paid to morphometric analysis (*e.g.*, Fagerstrom, 1982), and a much broader concept of the stromatoporoid species has ensued. The species concept we apply here is a relatively broad one (Stearn, 1989a).

Many stromatoporoid species demonstrate significant structural or morphometric variability. In many species a large proportion of the range of variability may be expressed within a single skeleton. In general, a grouping of specimens may be confidently considered a unique species when the range of variability (however broad) is continuously expressed across the full collection, with no major gaps or discontinuities. An obvious precondition for recognizing the range of variability is a relatively large number of specimens. A good indication of the broad species concept as applied herein is shown by a comparison of total species diversity with generic diversity. The Arctic Emsian stromatoporoid fauna comprises 25 species in 22 genera; only two genera are represented by more than a single species.

A consequence of a broad species concept is that, in our opinion, the notion of subspecies is generally inapplicable to stromatoporoids. Because variability within a species is already great, rarely (if ever) will a given population consistently demonstrate characteristics deserving subspecies rank.

Species synonymies listed are meant to be all-inclusive, listing all species considered identical to the species being described. Those species described as *confere* (*cf.*) to an earlier description have the compared references listed in the synonymy (following *cf.*). *Confere* (*cf.*) is the only nomenclatorial qualifier employed here. It is used for described species that closely resemble those described elsewhere. Reservation may be due to minor morphologic differences, too small a sampling to assure that the full range of variability is present, or inadequacies in the original description. Expanded study of such species may ultimately demonstrate that they are the named species (delete *cf.*) or, much less likely, that they are separate but closely related species.

Species-level taxa are distinguished by letters (*e.g.*, *Actinostroma* sp. A) when we judge that a distinctive morphology is exhibited that is likely to result in a new species being described when more and better specimens have been studied. If the material is sufficient for a generic identification only, the generic name is modified only by sp. (*Trupetostroma* sp. = a species of *Trupetostroma*).

In the course of this study, approximately 800 thin-sections were examined. The preservation of identified specimens is graded according to the scale: exceptionally well preserved; well preserved; moderately well preserved; mediocre; poor. These categories are approximate and subjective, but in general imply the following. Exceptionally well preserved specimens preserve all macrostructure and especially microstructure in very fine detail, uniformly throughout the specimen; specimens of this quality are exceedingly rare. Well preserved specimens show little or no diagenetic alteration; macrostructural details are fully preserved, and original microstructures are preserved over most of the specimen. Moderately well preserved specimens show some diagenetic alteration; macrostructure is largely unaffected, but microstructural detail may be obscured, although it is generally preserved at least locally. Most identified specimens are either well or moderately well preserved. Mediocre preservation applies to specimens in which macrostructural details are obscured, at least partly, and no original microstructural detail remains; specimens so preserved remain identifiable on macrostructural grounds only. Poorly preserved specimens preserve no microstructural detail, and macrostructures are largely obscured. In general, poorly preserved specimens cannot be confidently assigned (to species) in isolation, but can be identified in the context of the full collection studied.

The value of classifying the preservation of specimens (in combination with the number of specimens identified) is that it allows the reader to gauge independently the confidence of the species identifications/descriptions. This is particularly true for newly described species.

Morphological measurements provided are in metric units, commonly centimetres (cm), millimetres (mm), or micrometres (μm). Most measurements are derived from thin-section examination. Most frequently cited morphological parameters are laminar and pillar spacing, and laminar and pillar thickness. Laminar and pillar spacing are conventionally expressed as number of laminae/pillars occurring per 2 mm distance, commonly cited as an average of n measurements with a minimum and maximum range of values per specimen or species.

Morphological terminology follows the established literature on stromatoporoid systematics. Definitions of recently introduced terms may be found in such papers as Stearn, (1989b, 1991, 1993) and Stock (1989). Introductory glossaries appear in older papers such as Galloway and St. Jean (1957). In this report, we deviate from the normal terminology only for the following morphological feature. Where astrorhizae in tangential section are without walls and defined only by areas devoid of structural elements, the term "canal" or "tube" is inapproporiate; we use the term "astrorhizal path" or "path".

Type specimens designated in this report are housed in the Type Collection at the Geological Survey of Canada, Ottawa, Ontario, and are identified with a six-digit number with the prefix GSC (*e.g.*, GSC 108863). The locations from which these specimens were collected are listed in Appendix 2. The precise location of collections is recorded by latitude and longitude in Appendices 1 and 2 because very few geographic names are available in the High Arctic. Appendix 3 is a catalog of the other specimens identified in this study with their collection localities referenced to Appendix 1 and Text-figure 1. These specimens are in the general collections of the Geological Survey in Ottawa marked with a prefix number 110, 111, 120, or 129 followed by a hyphen and a second number (e.g., 110-286). The few types referred to by the prefix ROM are from the collection of the Royal Ontario Museum, Toronto, Ontario, Canada.

SYSTEMATICS

Class **STROMATOPOROIDEA**
Nicholson and Murie, 1878

Order **ACTINOSTROMATIDA**
Bogoyavlenskaya, 1969

Family **ACTINOSTROMATIDAE** Nicholson, 1886

Genus **ACTINOSTROMA** Nicholson, 1886

Type species.—*Actinostroma clathratum* Nicholson, 1886.

Actinostroma sp. A
Plate 1, figures 1–3

Description.—Skeleton large, hemispherical; surface bearing low mamelons closely and regularly spaced; no astrorhizae visible on surface.

Vertical section: Laminae thin, flat or very gently undulate, consistently parallel, commonly passing laterally into a series of dots; thickness 0.02–0.04 mm, where poorly preserved may thicken to 0.06–0.08 mm; spaced 7 to 10 per 2 mm, average 8.3 (n=30). Latilamination absent, although successive spacing phases (vertical gradations of distantly to closely spaced laminae) 0.4–0.5 mm thick generally present. Pillars regularly spaced, 9 to 10 per 2 mm, average 8.9 (n=30); thickness variable, 0.04–0.08 mm, average 0.06 (n=30); apparent vertical length limited, commonly span 1 to 5 laminae; maximum observed length 3 mm, long pillars generally slightly bent, rarely straight. Astrorhizae uncommon, inconspicuous, defined by zones of gentle laminar doming, interlaminar dilation, and upward-divergent pillars; apparent vertical canal width 0.3–0.5 mm. Dissepiments scattered. Skeletal microstructure compact.

Tangential section: In interlaminar areas, pillars form isolated dots, 0.04–0.06 mm diameter, a few joined by or bearing partial colliculi; towards and into laminar bands, pillars colliculate, forming polygonal network; colliculi 0.01–0.02 mm thick. Preservation of colliculi variable, poorly or unpreserved in much of specimen. Dissepiments log, arcuate lines joining several pillars. Astrorhizae small, ill-defined, indicated by vague paths of absent skeletal elements at and near mamelon summits; lateral path width approximately 0.2 mm.

Material.—Large fragment of a single specimen *ca.* 40 cm basal diameter by 20 cm high. Hypotype GSC 108852. Well preserved.

Discussion.—This specimen probably represents a new species of *Actinostroma,* but, despite locally excellent preservation, one specimen is insufficient material to establish the species.

Since Flügel's (1959) monographic treatment of the genus *Actinostroma,* many species have been added, still others removed to *Plectostroma* and *Densastroma.* Nonetheless, the basic species groupings recognized by Flügel (1959) remain valid. Of the three main Devonian *Actinostroma* species-groups outlined by Flügel (*A. clathratum, A. hebbornense,* and *A. stellatum* species-groups), this Arctic species shows closest affinity to species of the *A. hebbornense* group: thin laminae and pillars, both spaced about 5 per mm. Species from all three of these Devonian groups are most plentiful in the Givetian and Frasnian, but one Eifelian species, *A. perspicuum* Počta, 1894, shows interesting parallels to *Actinostroma* sp. A. *Actinostroma perspicuum* has similar thin laminae and thin, relatively short pillars, but it is markedly cystose and has commonly convergent laminae. Although the Bohemian *A. perspicuum* (Choteč Limestone) and the Arctic specimen do not therefore appear to be closely related, both are characterized by very thin structural elements, primitive representatives of a general trend towards elemental thickening exhibited by later Givetian and Frasnian species (Flügel, 1959).

Occurrence.—Truro Island, unnamed limestone formation; highest Emsian/basal Eifelian (undifferentiated *patulus* Zone).

Genus **PLECTOSTROMA** Nestor, 1964

PLECTOSTROMA SALAIRICUM
(Yavorsky, 1930)

Type species.—*Actinostroma intertextum* Nicholson, 1886.

Plate 1, figures 4,5

Actinostroma salairicum Yavorsky, 1930, p. 489–490, pl. II, figs. 1–3.
Plectostroma salairicum (Yavorsky, 1930). Flügel and Flügel-Kahler, 1968, p. 376.
? *Actinostroma salairicum* Yavorsky. Khromych, 1984, p. 113–114, pl. VI, fig. 1.

Description.—Skeleton laminar to weakly domed, up to 10 cm diameter. Surface smooth; astrorhizae inconspicuous in hand-specimen.

Vertical section: Dense network of pillars and subordinate colliculate laminae. Pillars 0.03–0.05 mm thick; spaced 6 to 8 per mm, average 7.0 per mm (n=20, combined specimens); vertical extent variable 0.3–1.5 mm, commonly 0.5 mm; commonly thicker/more opaque than colliculi; irregular thin phases of very dark pillars grossly resemble latilaminae, but true latilaminae absent. Colliculi thin 0.02–0.03 mm; commonly arched (between neighbouring pillars), fewer straight/horizontal; dominantly arise at uniform levels to impart horizontal fabric to skeleton, locally network irregular; where colliculate laminae occur, spacing 7 to 9 per mm, commonly 7 to 8 per mm, specimen GSC 108853 average 7.8 range 7 to 9, GSC 108854 average 7.7 range 7 to 9 (each n=10). Skeletal microstructure compact. Astrorhizae prominent, vertically persistent; axial canal 0.20–0.30 mm diameter, canal walls 0.04–0.05 mm thick; lateral canals branching downward from axial canal; astrorhizal tabulae (resembling enlarged colliculi) abundant, one for every three to five colliculate laminae. Dissepiments absent.

Tangential section: Pillars dark, solid dots 0.02–0.04 mm diameter; either isolated, or tightly linked by colliculi into network; four, less commonly five, colliculi arise from each pillar. Astrorhizae simple, single axial canal surrounded by a few simple lateral canals, 0.12–0.20 mm wide average 0.15 mm; center-to-center spacing 5 to 7 mm.

Material.—Two specimens. Hypotypes GSC 108853, 108854. Well preserved.

Discussion.—Yavorsky's (1930) original description and illustrations of *Plectostroma salairicum* closely match the Arctic specimens, and only a minor difference in pillar spacing distinguishes the two (5 to 6 per mm for Yavorsky's specimens, 6 to 8 per mm for those herein). The astrorhizal systems of the Arctic and Yavorsky's specimens, however, are identical.

Yavorsky (1930, p. 489) noted the locality of *P. salairicum* as "Kuznetsk Basin, Kara-Chumysh River, in beds with *Pentamerus pseudobaschkiricus* Tschern." (now referred to *Zdimir pseudobaschkiricus*). The *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone includes mixed elements of both the *patulus* and *partitus* Zones (conodonts), and is therefore uppermost Emsian and/or lowest Eifelian (Rzhonsnitskaya, 1988). This matches the age of the Bathurst Island unnamed formation, as currently understood (undifferentiated *patulus* Zone).

Differences of opinion persist as to the assignment of species such as *P. salairicum* to the genera *Plectostroma* or *Actinostroma.* As noted by Nestor (1964, p.109), in the generic definition of *Plectostroma,* "the difference consists (sic) in the connective processes, which in *Plectostroma* are distributed irregularly, but in *Actinostroma* they occur on definite levels and form regular, concentric laminae." Various species, however, demonstrate differing degrees of collicular irregularity versus alignment. At one extreme, the type species of *Plectostroma, P. intertextum* (Nicholson, 1886), shows random distribution of colliculi. Other species, such as *P. necopinatum* Nestor, 1964, show rare collicular alignment. Near the opposite extreme, species such as *P. salairicum* have many more colliculi in alignment than are not, a fact that has prompted Khromych (1984) to retain *P. salairicum* in the genus *Actinostroma* (but see below). Still, a strictly statistical distinction between *Plectostroma* and *Actinostroma* (on the basis of proportions of aligned versus unaligned colliculi) would obscure important relationships between species that are clearly related and intergradational in nature. As Stock (1979) has noted, *Plectostroma* represents a useful grouping of species intermediate in skeletal element size and spacing between *Actinostroma* and *Densastroma* (this latter with a very fine skeletal network). This broader approach follows that of Flügel and Flügel-Kahler (1968) and Flügel (1974), who initially reassigned *Actinostroma salairicum* Yavorsky to *Plectostroma.*

The assignment by Khromych (1984) of specimens to *Actinostroma salairicum* Yavorsky is questionable. Khromych's Siberian specimens have more distantly spaced and thicker structural elements than either Yavorsky's (1930) or those herein (3 to 4 pillars per mm; 5 "laminae" per mm; pillars 0.12–0.15 mm thick; "laminae" 0.08–0.10 mm thick; Khromych, 1984).

Flügel (1974, p. 178) tabulated the major morphologic features of six Devonian species of *Plectostroma,* including *P. salairicum.* An additional five Devonian species from the former Soviet Union are listed by Bogoyavlenskaya and Khromych (1985).

Occurrence.—Bathurst Island, Dyke Ackland Bay; unnamed limestone, lower 100 m; uppermost Emsian/basal Eifelian (undifferentiated *patulus* Zone).

Genus **ACULATOSTROMA** Khalfina, 1968

Type species.—*Syringostroma verrucosum* Khalfina, 1961.

Aculatostroma cf. **A. kaljanum**
(Bogoyavlenskaya, 1977)
Plate 2, figures 1–5

cf. *Coenellostroma kaljanum* Bogoyavlenskaya, 1977, p. 15, Pl. 4, figs. 1a, 1b.

Description.—Skeleton laminar to gently wavy, up to 10 cm.

Vertical section: Laminae colliculate, mostly continuous, very gently undulate; on a fine scale, ragged not smooth; locally inflected into shallow impersistent mamelons; thin, 0.02–0.04 mm, commonly diagenetically thickened to 0.05–0.06 mm; spaced regularly, 8 to 11 per 2 mm, average 9.7 (n=10). Pillars short, confined to interlaminar interval, generally offset between successive laminae, rarely superposed; 0.04–0.06 mm thick, locally thickened to 0.08 mm; spaced regularly, 8 to 11 per 2 mm, average 9.4 (n=10). Colliculi arise sharply off pillars, forming vaulted cell-shaped galleries. Skeletal microstructure compact. Astrorhizae abundant, poorly formed; axial canals vertically impersistent, roughly 0.6–0.8 mm diameter, many inclined, may or may not be accompanied by impersistent mamelons; astrorhizal tabulae abundant, crowded, thin 0.01–0.02 mm (but may be greatly thickened by diagenesis), dominantly sub-horizontal, flat or broadly convex, locally concave; lateral branches and tributaries indicated by lenticular or irregular zones of tabulae. Dissepiments (smaller than tabulae) in skeletal galleries, common not abundant. Latilaminae 3–4 mm thick, may be floored by thin band of sediment and thick (1–1.5 mm) basal layer of disordered skeletal material; thick root-like basal layer forms floor of specimen GSC 108855.

Tangential section: Laminae diffuse meandering bands. Pillars vermiform or cateniform, locally linked into network; 0.04–0.06 mm thick; about one-quarter of pillars dot-like, 0.04–0.06 mm diameter; commonly linked by finer elements, either partial colliculi or dissepiments, 0.01–0.02 mm thick. Astrorhizae scattered, discontinuous, irregularly branching segments, *ca.* 0.6 mm diameter; tabulate, or locally empty; generally, not exclusively, at mamelon summits.

Material.—Two fragmentary specimens, one well preserved, one poorly preserved. No growth surfaces preserved. Hypotype GSC 108855. Second specimen 110-132.

Discussion.—This species demonstrates similarities to *Aculatostroma kaljanum* (Bogoyavlenskaya) from the *karpinskii* horizon (Emsian, *gronbergi–inversus* Zones; Khodalevich *et al.,* 1982), eastern slope of the northern Urals. Bogoyavlenskaya's (1977) description is sketchy, and precludes thorough comparison. Laminar spacing of *A. kaljanum* is noted as 4 per mm, laminar width 0.07–0.1 mm, and pillar thickness "does not exceed 0.1 mm" (Bogoyavlenskaya, 1977, p.15). The cited thicknesses exceed those of the Ellesmere specimens, but Bogoyavlenskaya's illustration (1977; Plate 4, fig. 1) suggests laminae and pillars approximately 0.05 mm thick. Significantly, Bogoyavlenskaya (1977, p.15) describes the astrorhizae as "numerous and simple", and "astrorhizal tabulae numerous, arranged parallel to laminae", the same condition as in the Ellesmere specimens. Additionally, Bogoyavlenskaya noted the occurrence of an "epitheca" (0.5 mm thick) on the undersurface of some specimens; a potentially similar structure, a digitate, root-like basal phase of disordered skeletal material, is present in one of the Ellesmere specimens (GSC 108855). This last feature, while interesting, is of negligible taxonomic value because it is an abnormal growth phenomenon.

Considerable uncertainty has surrounded the generic assignment of species to either of *Aculatostroma* or *Atelodictyon,* and whether *Aculatostroma* itself is an actinostromatid (colliculate laminae) or a clathrodictyid (continuous laminae) (see Stearn, 1991). For the most part the fine structure of Ellesmere *Aculatostroma* cf. *A. kaljanum* is diagenetically obscured, but a few thin zones of one or two laminae (occurring beneath sediment interlayers) preserve skeletal elements in extreme detail. Plate 2, figures 4 and 5 depict the colliculate pillars found in such a zone; note how the colliculi arise sharply, parasol-like, off the short pillars.

The astrorhizae of *Aculatostroma* cf. *A. kaljanum* are unusual in their disordered arrangement, abundance of near-horizontal tabulae or cysts, and apparent facultative association with mamelons. It is possible that they instead represent intergrowths of commensal or parasitic organisms. Plate 2, figure 3 presents supplementary evidence to suggest that the tubes are indeed astrorhizal canals, albeit aberrant ones; on this slabbed, tangential surface, the tubes can be seen to radiate from a central area, branching dichotomously and slightly thinning outward. Such a horizontal pattern is inconsistent with the commensal habit of a foreign organism (such as *Syringopora*), and the abundant horizontal tabulae mitigate the possibility of an invading borer. The common occurrence of these tubes in the arctic specimens and those from the Urals [*A. kaljanum* (Bogoyavlenskaya)] implies that the structures are intrinsic to the stromatoporoid, rather than a the product of a chance guest or invading organism.

The preservation of the Ellesmere specimens deserves some additional mention. As noted in the description, skeletal elements (laminae, pillars, dissepiments, tabulae) are commonly thickened, in some specimens by as much as 10 times the original thickness. Periodic, thick (0.5–1.0 mm), dark bands parallel the laminae in specimen GSC 108855, and they are confluent with, and appear to be composed of, the same material as the skeletal elements. The dark bands, of diagenetic origin, occur at the same periodicity as latilaminar boundaries (elsewhere indicated by thin sediment interlayers). In thin section, ghosts of skeletal elements are discernable within the thick bands, i.e., the bands are not part of the original skeletal architecture. Rather, they appear to be preferentially nucleating at latilaminar bases. Where the bands are thickest (especially within the basal layer), their crystalline habit is bundled, and their optical characteristics suggest fascicular-optic calcite (*sensu* Kendall, 1977). This latter is generally considered strictly a void-filling fabric, but in this instance it appears to be displacive (replacement).

A second specimen, not as well preserved as the one described and illustrated is also assigned to this species. In the second specimen, laminar spacing is slightly closer than in GSC 108855, 7 to 9 per 2 mm, and it displays slightly fewer astrorhizal canals, although equally poorly formed.

Occurrence.—Blue Fiord Formation, lower 100 m; Vendom Fiord (GSC 108855), Eids Fiord (one specimen); lower Emsian (*dehiscens* Zone).

Order **CLATHRODICTYIDA**
Bogoyavlenskaya, 1969

Family **CLATHRODICTYIDAE** Kühn, 1927

Genus **CLATHRODICTYON**
Nicholson and Murie, 1878

Type species.—*Clathrodictyon vesiculosum* Nicholson and Murie, 1878.

Clathrodictyon ellesmerense Stearn, 1983
Plate 3, figures 1–3

Clathrodictyon ellesmerense Stearn, 1983, p. 545, 547, fig. 3A–3E; 1989a, fig. 1A.

Material.—Twenty-one specimens; poorly to moderately well preserved. Hypotypes GSC 108856 to 108858. Other specimens at Geological Survey listed in Appendix 3.

Discussion.—This species was established by Stearn (1983) for specimens collected from the lower Blue Fiord Formation in the vicinity of the type section. The majority of specimens of *Clathrodictyon ellesmerense* in this study come from equivalent localities on Ellesmere Island, ranging from *dehiscens* to *gronbergi* Zones (lower Emsian). Additional specimens of *C. ellesmerense* from the Bird Fiord Formation of Ellesmere Island and from Bathurst Island extend the stratigraphic range of this species to lowest Eifelian.

The additional specimens of this study expand the morphological parameters of *Clathrodictyon ellesmerense* from the original description of Stearn (1983). The new specimens demonstrate a greater range of laminar spacing than do those in the original collection (about 11.5 per 2 mm; Stearn, 1983); pillar spacing and the thickness of the skeletal elements are within the originally cited ranges. In the additional specimens, laminar spacing ranges from about 10 to 15 per 2 mm, with the majority of specimens measuring 10 to 12 laminae per 2 mm.

Specimens with especially closely spaced laminae may demonstrate these distinctive features: 1) repeated variations in laminar spacing (=successive phases); and 2) local development of vertically impersistent papillae. Of the 13 specimens of *Clathrodictyon ellesmerense* from the lower Blue Fiord Formation, two display successive phases of growth in which laminar spacing changes from a minimum of 8 per 2 mm progressively up to 16 per 2 mm, over vertical distances of 3 to 5 mm (Pl. 3, fig. 1). Such rhythmic changes may indicate seasonal variation in growth rate (Stearn, 1989a). Another two of the Blue Fiord specimens of *C. ellesmerense* display discrete protuberances measuring 1–2 mm wide by 2–3 mm high (Pl. 3, fig. 3). They are formed as small domal inflections of the laminae and are vertically limited and not associated with astrorhizal canals. In thin section, no distributional pattern of the protuberances is readily apparent within the skeleton, but one hand-specimen suggests they occur at growth interruptions, and may be an intrinsic response to unfavourable environmental conditions.

As noted earlier by Stearn (1983), some specimens of *Clathrodictyon ellesmerense* display dense intergrowths of syringoporid corals.

Occurrence.—Blue Fiord Formation; lower 100 m, type area (15 specimens); lower member, Vendom Fiord (two specimens); lower Emsian (*dehiscens-gronbergi* Zones). Blue Fiord Formation, upper member, Vendom Fiord (one specimen); Disappointment Bay Formation, Truro Island (one specimen); *inversus* Zone. Bird Fiord Formation, Ellesmere Island, type area (one specimen); Northeastern Bathurst Island, unnamed limestone formation (one specimen); highest Emsian-basal Eifelian (undifferentiated *patulus* Zone).

Genus **GERRONOSTROMA** Yavorsky, 1931

Type species.—*Gerronostroma elegans* Yavorsky, 1931.

Gerronostroma septentrionalis, new species

Plate 3, figures 4, 5; Plate 4, figures 1–4

Gerronostroma sp. A Stearn, 1983, p. 547–548, figs. 4A, 4B.

Diagnosis.—Thin laminae, closely but variably spaced 9 to 18 in 2 mm; pillars thin, spaced regularly and closely, 11 to 20 in 2 mm; dissepiments uncommon.

Description.—Skeletal form variable, laminar to weakly domical, commonly irregular, rarely bulbous. Surfaces poorly exposed, apparently bearing numerous, small mamelons. Latilaminae common, thickness 0.7–1.0 cm.

Vertical section: Laminae continuous, flat or gently undulate, less commonly highly undulate-to-irregular; thin, 0.03 to 0.04 mm, rarely to 0.05 mm; in specimens with syringoporids, deflected slightly downward at corallite margins. Laminar spacing very close, but highly variable; species range 9 to 18 per 2 mm, commonly 13 to 16 per 2 mm; holotype GSC 108859 average 15.2 (n=20) range 13 to 18, paratype GSC 108860 average 15.5 (n=10) range 13 to 17, paratype GSC 108862 average 14.2 (n=10) range 13 to 16. Successive phases of laminar spacing common, 1.5 to 2.0 mm thick, or about four to five phase-cycles per latilamina; where closely spaced, rare pairs of laminae may be tightly adpressed, separated by gap of 0.01 to 0.02 mm. Basal phase of stringy material 0.2 to 0.3 mm thick at base of latilaminae, also as thin lenses irregularly throughout skeleton; some latilaminar surfaces show minor erosion (truncated or missing upper laminae). Pillars thin, 0.02–0.04 mm; generally superposed through interval of 2 to 10 laminae, although readily lost to diagenesis; dominantly simple, straight, rod-shaped; a few slightly thickened or apparently split upward; spacing variable, generally very close and regular, species range 11 to 20 per 2 mm, commonly 13 to 17 per 2 mm, holotype average 16.5 (n=20) range 14 to 20, paratypes GSC 108860 average 15.0 range 13 to 17, GSC 108861 average 13.5 range 12 to 15, GSC 108862 average 15.1 range 13 to 17 (all n=10); tending to be closer where laminae closely spaced. Astrorhizae variably present, common or abundant in most specimens, in a few rare or absent, consisting of central bundle of few vertical canals 0.1 to 0.2 mm diameter, and many smoothly curved lateral branches merging into galleries; associated with shallow mamelons, vertically persistent up to full latilaminar height; pervasive lateral branches as small circular gaps 0.2 mm diameter or short tubes locally interrupting laminae, abundant near axis and along certain levels; absent or imperceptible in specimens with commensal syringoporids. Dissepiments uncommon except in areas of skeletal repair. Skeletal microstructure compact, minutely speckled; some specimens irregularly fibrous.

Tangential section: Laminae dense meandriform bands. Pillars commonly small dots, 0.02–0.04 mm diameter, or short vermiform strands; closely spaced, about 0.04 mm apart. Astrorhizae axial bundle of three to five canals and surrounding dense array of outward-branching lateral canals; canal width 0.1 to 0.2 mm; complexity and density highly variable between specimens, closest center-to-center spacing about 5 mm.

Material.—Twenty-four specimens, mostly well-preserved. Seven specimens with commensal syringoporids, seventeen without. Holotype GSC 108859; paratypes GSC 108860 to 108862. Other specimens listed in Appendix 3.

Discussion.—*Gerronostroma septentrionalis* n. sp. demonstrates extremely broad variation in laminar and pillar spacing, astrorhizal arrangement and abundance, and overall growth form. It is the same species recognized earlier by Stearn (1983) as *Gerronostroma* sp. A (also from the lower Blue Fiord Formation, Ellesmere Island). Minor differences between the earlier description and this one are attributable to the broad specific variation of *G. septentrionalis* n. sp., not fully represented in the small collection of Stearn (1983). The earlier description noted the astrorhizae as being inconspicuous and latilamination as not prominent, which by the present species-concept are more exceptions than the norm. The pillar spacing cited by Stearn (1983), 11 to 12 per 2 mm, is within the range of *G. septentrionalis* n. sp., although low; laminar spacing for *G.* sp. A Stearn, 1983, is 16 to 18 per 2 mm. The new specimens of *G. septentrionalis* n. sp. demonstrate roughly a one-to-one ratio of pillar to laminar spacing (for any specimen or uniform region within a specimen). The apparent disparity exhibited by the specimens of Stearn (1983) is due to preferential diagenetic loss of pillars, a feature consistently evident in both collections. Some specimens show partial or complete removal of pillars, leaving only the closely spaced laminae intact.

Another specimen referred by Stearn (1983) to *Gerronostroma* cf. *G. immemoratum* Bogoyavlenskaya is not conspecific with *Gerronostroma septentrionalis* n. sp. Its laminar and pillar spacings are well outside the range of *G. septentrionalis* n. sp. and, moreover, its skeletal element thicknesses are much greater. Considering the geographic and stratigraphic similarity of the collection of Stearn (1983) and those herein, the absence of new specimens similar to *G.* cf. *G. immemoratum* is puzzling. Still, the species appears to be valid, and the paleogeographic relationship to the eastern Urals suggested by *G.* cf. *G. immemoratum* is supported by the present evidence (see under occurrence of *Aculatostroma* cf. *A. kaljanum*, p. 17).

G. septentrionalis n. sp. shows little similarity to other known species of *Gerronostroma*. Two lower Emsian species are described by Lessovaya (1970) from the Zeravshan Range, Uzbekistan: *Gerronostroma istekense schirdagica* Lessovaya has much thicker skeletal elements, more widely spaced, than *G. septentrionalis* n. sp.; and *Gerronostroma uralicumforme* Lessovaya appears more reasonably to belong to *Atopostroma* Yang and Dong. Of the three upper Lochkovian species of *Gerronostroma* described by Stearn (1990) from the Stuart Bay Formation, Bathurst Island, none is closely comparable to *G. septentrionalis* n. sp.

About one-third of the specimens of *Gerronostroma septentrionalis* n. sp. exhibit dense intergrowths of a syringoporid coral (e.g. Pl. 4, fig. 3). The intergrown corallites are either very abundant or completely absent, i.e., there is no intermediate condition of just a few intergrown corallites. This implies that the relationship between the coral and *G. septentrionalis* n. sp. is neither accidental nor parasitic, for which a gradation of intergrowth densities should occur. Mutualism is unlikely, as *Gerronostroma* specimens without the coral are abundant and show no obvious signs of lesser growth than those with the coral. Rather, strict commensalism on the part of the coral is indicated.

Gerronostroma septentrionalis n. sp. is commonly found competitively overgrowing other stromatoporoid species (primarily *Stromatopora polaris* Stearn and *Stictostroma*? *nunavutense* n. sp.). A third of the specimens demonstrate this overgrowth, and of these, three specimens (including the holotype) show intimate interfingering of the competing stromatoporoids. In the holotype (GSC 108859), at least five such interfingering episodes occur within one latilamina of *G. septentrionalis* n. sp. (Pl. 4, fig. 4). The overtopping/recolonization by *Gerronostroma* is in each instance clearly defined by a characteristic mat of basal stringy tissue. By the end of the latilaminar event, the competing species appears to have been excluded from the holotype specimen, and indeed in each example observed *Gerronostroma* ultimately overgrows the other in vertical succession.

Etymology.—Latin *septentrionalis,* of, or from the north.

Occurrence.—Blue Fiord Formation, lower member; Ellesmere Island, vicinity formation type area (21 specimens), Vendom Fiord (two specimens); lower Emsian (*dehiscens* Zone). Uppermost Eids Formation, Eids Fiord, Ellesmere Island (one specimen); lower Emsian (*dehiscens* Zone).

Genus **PETRIDIOSTROMA** Stearn, 1992,
(*nom. subst. pro Petrostroma* Stearn, 1991
non Petrostroma Döderlein, 1892)

Type species.—*Simplexodictyon simplex* Nestor, 1966.

Petridiostroma sp.
Plate 5, figures 1–2

? *Anostylostroma laxum* Nicholson. Stearn, 1990, p. 503–504, figs. 3.3–3.5.

Description.—Skeleton laminar to irregular. Latilaminae about 5 mm thick evident in some specimens.

Vertical section: Laminae continuous, gently undulate; 0.04–0.06 mm thick, commonly 0.05 mm thick; spaced 6 to 8 per 2 mm, specimen averages 7.5 (GSC 108863), 6.3 (GSC 108864) (each n=10); microstructure compact. Pillars simple, commonly rod-shaped, some slightly thickening upward to meet overlying lamina, rarely branching upward; 0.04–0.08 mm thick, average 0.055mm (GSC 108863; n=20); variably spaced, 7 to 11 per 2 mm, specimen averages 8.8 (GSC 108863), 8.5 (GSC 108864) each n=10; arrangement between successive laminae irregular, random, pillars neither consistently staggered nor superposed; locally absent for lengths up to 1.0 mm. Dissepiments common, broadly convex; thin 0.02 mm.

Tangential section: Pillars solid dots 0.04–0.08 mm diameter; rarely incomplete small circles with clear center, diameter up to 0.12 mm. Dissepiments conspicuous, shallow arcs or irregular segments bridging pillars. Astrorhizae absent.

Material.—Three specimens, ranging from poorly to moderately well preserved. Hypotypes GSC 108863, 108864. Other specimen 111-1.

Discussion.—These few specimens from Ellesmere Island are best assigned to the genus *Petridiostroma* (Stearn, 1992) on the basis of their planar laminae and predominantly simple pillars. They are quite similar to specimens from the upper Lochkovian of Bathurst Island ("Stuart Bay" Formation) referred to *Anostylostroma laxum* by Stearn (1990). The Bathurst Island specimens have more distantly spaced laminae (ten-count average of 5.5 in 2 mm in one specimen, 7.1 in the other) and pillars (ten-count average of 5.5 in 2 mm in one specimen, 6.2 in 2 mm in the other) than do those described here, but they are otherwise closely comparable. In light of recent study (Stearn, 1991), *Anostylostroma* should be restricted to species in which the majority of pillars branch-upward irregularly and complexly. As such, the Lochkovian specimens referred to *Anostylostroma laxum* by Stearn (1990) should be reassigned to *Petridiostroma*. These Lochkovian specimens show a predominance of simple pillars, and only a few are Y-shaped (Stearn, 1990). Re-examination of the specimens reveals that less than one per cent of the pillars branch, a proportion comparable to the Ellesmere Island *Petridiostroma* sp. specimens. Tangential sections are especially diagnostic, for although the few branched pillars appear prominent in vertical section, tangentially the overwhelming majority of pillars are dots. Nonetheless, more specimens of the Ellesmere Island *Petridiostroma* sp. are needed to support a definite relationship to the Lochkovian specimens. *Anostylostroma laxum* (Nicholson, 1887) itself (*cf. e.g.*, Fagerstrom, 1982; Bjerstedt and Feldmann, 1985) is best assigned to the genus *Schistodictyon* (pillars branch upward dichotomously) (Stearn, 1991).

Occurrence.—Blue Fiord Formation, Ellesmere Island; Goose Fiord, dolomitic facies (one specimen), mid-Emsian (*inversus* Zone); Vendom Fiord, near base of upper member (two specimens), lower Emsian (*inversus* Zone).

Genus **ATELODICTYON** Lecompte, 1951

Type species.—*Atelodictyon fallax* Lecompte, 1951.

Atelodictyon cf. **A. solidum** Khromych, 1976
Plate 5, figures 3,4

cf. *Atelodictyon cylindricum solidum* Khromych, 1976, p. 48, pl. IV, figs. 4a, 4b, 4c.

Description.—Fragmentary; skeleton laminar.

Vertical section: Laminae thin, 0.02–0.03 mm, locally thickened to 0.05 mm; mostly continuous, but locally broken, due either to poor preservation or penetration by astrorhizal canals; spaced 4 to 5 per 2 mm; irregularly undulate, interlaminar spaces locally swollen or pinched out. Coenosteles complex, thin; dominantly vertical, but irregularly sinuous, crumpled. Two types of coenosteles occur (with numerous intergradational forms): dominantly 1) thin, 0.02–0.04 mm, tightly crowded, paired or in interwoven hairlike bunches, commonly splaying upward to meet overlying lamina; subordinately 2) thicker, up to 0.10 mm, thickening or splitting upward to meet lamina. Coenostele spacing 8 to 11 per 2 mm, average 9.5 (n=10), but locally tightly crowded and individuallly indiscernable. Astrorhizae large, extensive, composed axially of vertical bundles of canals, each 0.4–0.5 mm wide, spread laterally like buttressed roots of a tree; astrorhizal tributaries widely scattered, form hollow circles or short tubes, commonly truncating laminae. Dissepiments uncommon, thin, broadly convex, mostly preservationally obscured. Microstructure probably compact.

Tangential section: Coenosteles vermiform to netlike; thickness variable, 0.03–0.08 mm; rarely dots 0.02–0.05 mm diameter; rarely irregularly ring-shaped; where netlike, enclosing galleries 0.2–0.5 mm across. Astrorhizae large, very prominent, axial canal diameter 0.4–0.5 mm; at optimal height of section forming rosettes, comprising a central bundle of 5 to 6 vertical canals, surrounding array of long ramifying lateral canals extending up to 1.5 cm; tributary canal segments 0.2–0.3 mm diameter scattered throughout skeleton; central canal margins generally well-defined, tributary canals less defined, merge into skeletal network. Distance between astrorhizal centres about 1.0 cm.

Material.—Two specimens, one moderately well preserved (GSC 108865), one poorly preserved (120-6).

Discussion.—These few but distinctive specimens compare favorably with *Atelodictyon solidum* Khromych, 1976, known from the Emsian of the Ulakhan-Sis Range, northeastern Siberia. Khromych (1976) noted the following characteristics of *A. solidum*: laminae 0.05 mm thick, spacing 5 to 10 per 2 mm; pillars 0.04–0.07 mm thick, spacing 10 per 2 mm; astrorhizal canals 0.55 mm wide, distance between neighboring astrorhizae 9.1 mm. Morphometric differences between this and the Ellesmere specimens are therefore minor, with the possible exception being the more closely spaced laminae of Siberian *A. solidum*. Shared features of primary importance are the nature and disposition of the coenosteles, and particularly the large, pervasive astrorhizae, which are identical in the Siberian and Ellesmere Island specimens. Any reservation expressed in the assignment of the Ellesmere specimens is principally due to the limited material available, rather than to morphologic differences, which are within an acceptable range of specific variability.

Atelodictyon solidum was originally described as a subspecies *A. cylindricum solidum* Khromych, 1976. *Atelodictyon cylindricum* Khromych, 1971 is an unusual species with a cylindrical or spherical growth form; it occurs in the Lower Devonian (?Lochkovian-Pragian) Nelyudimskaya Suite of the Omulevski Mountains, northeastern Siberia. In consideration of age and morphologic differences, we elevate *A. c. solidum* Khromych, 1976 to species level.

The exact age of *Atelodictyon solidum* Khromych is uncertain. Khromych (1976, p. 48) lists it as "Eifelian stage, lower Tababastaakhskaya Subsuite, Ulakhan-Sis Range." Traditionally Soviet geologists have set the Lower–Middle Devonian boundary much lower than in the West, in what is now considered Emsian. Only relatively recently have Soviet/Russian stratigraphers adopted international boundary-placements (*cf.* Rzhonsnitskaya, 1988). An additional complication with the northeast-Siberian material is that Khromych's (1974, p. 71–73; 1976, p. 40) correlations are based almost entirely on stromatoporoids alone, unsupported by other fossil groups. Allowing for these uncertainties, the age of the Tababastaakhskaya subsuite appears to be Emsian, probably mid-to-late Emsian, therefore comparable to the *inversus* Zone provenance of the Ellesmere specimens.

Due to the apparent incompleteness of the laminae of *Atelodictyon* cf. *A. solidum,* consideration was given to an assignment to the actinostromatid genus *Aculatostroma* (which also has vermiculate to cateniform pillars in tangential section; *cf.* Stearn, 1991). As noted in the description above, discontinuities in the laminae of this species are attributable to preservation (see below) and, moreover, to interruption by the pervasive astrorhizal system. Most importantly, the coenosteles (pillars) in vertical detail show no evidence of becoming colliculate at their tops; they mostly either splay apart into fine strands, or thicken to meet the lamina above, against which they are sharply abutted.

Atelodictyon cf. *A. solidum* exhibits unusual preservation, although common for other stromatoporoids from the same locality (the shallow-platform, dolomitic facies of the Blue Fiord of southwesternmost Ellesmere Island). Intraskeletal galleries of *A.* cf. *A. solidum* are filled with early-stage, opaque calcite cement, which is poorly transparent in thin-section. When viewed in transmitted light, skeletal elements and cement-filled galleries are nearly equally opaque, and indistinguishable. Examination and illustration of this species therefore had to be done in reflected light, which accounts for the murkier appearance of Pl. 5, figs. 3 and 4 compared to others.

Occurrence.—Blue Fiord Formation, Muskox Fiord, Ellesmere Island; mid-Emsian (*inversus* Zone).

Family **TIENODICTYIDAE**
Bogoyavlenskaya, 1965

Genus **ANOSTYLOSTROMA** Parks, 1936

Type species.—*Anostylostroma hamiltonense* Parks, 1936.

Anostylostroma anfractum, new species
Plate 6, figures 1–5

Diagnosis.—Laminae thin, spaced 7 to 10 in 2 mm; pillars variable, complexly upwardly branched or joined, distinctive in form in tangential section as short chains, geniculate strands, and triskelions.

Description.—Skeleton laminar to slightly domed.

Vertical section: Laminae continuous, gently undulate; thin, 0.03–0.04 mm, locally thickened to 0.05–0.06 mm; regularly spaced, 7 to 10 per 2 mm, specimen averages 9.2, 8.6, 9.5, 7.2 (GSC 108866 to 108869; each n=10); microstructure transversely fibrous or locally transversely porous. Pillars highly variable, mostly upward-branching, either irregularly or simply (Y-shaped); a few upward-thickening or rod-shaped; commonly confined to single interlaminar interval, a few superposed over 2 to 4 laminae. Pillar thickness 0.03–0.08 mm, commonly 0.05–0.06 mm; may thicken upward to as much as 0.20 mm at overlying lamina; spaced 7 to 10 per 2 mm, specimen averages 7.6, 8.8, 8.5, 9.0 (GSC 108866 to 108869; each n=10). Dissepiments common, generally not abundant; thin, 0.02 mm; long, broad, sub-horizontal, gently convex. Latilaminae absent, but thin (0.5–1.0 mm) basal phases of unordered skeletal material may occur overlying growth interruptions.

Tangential section: Laminae moderately dark bands, mostly 0.1–0.2 mm wide; gently meandering. Pillars isolated or interconnected strands, uniformly thick 0.02 mm diameter; strands commonly geniculate, composed of short straight portions (about 0.2 mm long) turning sharply at obtuse angles; shapes commonly approach a triskelion; a few strands interconnected, but not for great lengths; some isolated oblique or circular dots, 0.02 mm diameter, may be locally abundant; very rarely form irregular rings. Pillar microstructure transversely fibrous. Astrorhizae absent.

Material.—Four fragmentary specimens. Preservation mediocre to moderately well preserved. Holotype GSC 108866. Paratypes GSC 108867 to 108869.

Discussion.—*Anostylostroma anfractum* n. sp. is most clearly distinguished in tangential section by its pillars, which appear as angular, geniculate strands forming triskelions, short chains, or isolated masses. It has the most complex pillar arrangement of any species of *Anostylostroma,* which typically exhibit short vermiform pillars in tangential section. The pillars of *Anostylostroma confluens* Galloway and St. Jean, 1957, from the Givetian of Indiana, approach this form, but are not as interconnected as those of *A. anfractum* n. sp. The cross sections of the pillars of *A. confluens* cut in tangential section are short, vermiform or coalescing, and without the geniculate form of *A. anfractum* n. sp.

The regularity of pillars in tangential section belies the extreme variability of pillars in vertical sections of *A. anfractum* n. sp. Two factors complicate characterization of pillars in vertical aspect: generally mediocre preservation, and variation in proportions of different pillar types between specimens. In vertical section, two of the paratypes (GSC 108868 and 108869) exhibit the commonest pillar arrangement, dominated by complexly branching, irregular, commonly inclined pillars. A third paratype (GSC 108867) in contrast displays a more orderly arrangement of pillars, in which simple rods are comparatively common (Pl. 6, fig. 3). The holotype (GSC 108866) represents an intermediate case, with complex and simple pillars occurring in near equal proportions.

Etymology.—Latin *anfractum*: bending, winding, or circuitous. Describes the pillars in tangential section.

Occurrence.—Northeastern Bathurst Island; unnamed limestone formation, lower 100 m; highest Emsian/basal Eifelian (undifferentiated *patulus* Zone).

Genus **PSEUDOACTINODICTYON** Flügel, 1958

Type species.—*Pseudoactinodictyon juxi* Flügel, 1958.

Pseudoactinodictyon conglutinatum, new species
Plate 7, figures 1–4

Diagnosis.—Laminae thick, compounded of fusion of adjacent thin laminae, locally split like those of *Simplexodictyon,* widely spaced 2 to 4 in 2 mm; pillars robust, spooled or dividing upward, dotlike of sausage-shaped in cross section.

Description.—Skeleton domal to hemispherical, up to 10 cm diameter. Surface irregular, without perceptible mamelons or astrorhizae.

Vertical section: Laminae undulate; spacing wide, inconsistent, 2 to 4 per 2 mm, holotype (GSC 108870) average 3.3 (n=10); distance between successive laminae variable, commonly 0.30–1.40 mm, holotype (GSC 108870) average 0.65 mm range 0.40–1.00 mm (n=30), paratype (GSC 108871) average 0.76 mm range 0.35–1.35 mm (n=30), locally as much as 2.0 mm. Laminae compound, formed by fusion of adjacent thin laminae, either completely or incompletely; completely fused laminae thick 0.14–0.28 mm average 0.20 mm (n=20, combined GSC 108870 and 108871), no axial zone; incompletely fused twin laminae separated by thin gap ca. 0.02 mm, locally swollen forming flat-bottomed vacuities, lower twin lamina generally thinner 0.04–0.06 mm than upper twin 0.12–0.16 mm; laminae locally perforate, perforations/foramina occluded by dissepiments at or near laminar level. Pillars commonly simple spool-shaped, or upward-dividing Y-shaped; thick 0.12–0.20 mm, holotype (GSC 108870) average 0.13 mm paratype (GSC 108871) average 0.17 mm (each n=10); spacing variable, range 4 to 8, commonly 5 to 7 per 2 mm, holotype (GSC 108870) average 5.5 per 2 mm (n=20), paratype (GSC 108871) average 6.6 per 2 mm (n=10). Dissepiments common, locally abundant. Microstructure compact. Astrorhizae obscure, indicated only by vaguely defined zones of downturned laminae, inwardly inclined pillars, dense concentrations of dissepiments and laminar perforations.

Tangential section: Pillars solid dots 0.10–0.14 mm diameter, or thicker, irregular, sausage-shaped or confluent (toward upper laminae). Dissepiments common, locally abundant, linking just less than half of pillars. Interlaminar gaps and vacuities scattered but prominent, more prevalent/conspicuous than in vertical section.

Material.—Three partial skeletons, moderately well preserved. Holotype GSC 108870, paratype GSC 108871, specimen 111-19.

Discussion.—Compared to Middle Devonian species of *Pseudoactinodictyon, P. conglutinatum* n. sp. displays generally thicker structural elements and wider laminar spacing. The most closely comparable species are *P. juxi* Flügel, 1958 from the Givetian of Sauerland, Germany (Flügel, 1958), and *P. vagans* Parks, 1936 from the Detroit River Group (probably Emsian) of Ontario and Ohio (Fagerstrom, 1982). The spacing of both laminae and pillars is roughly one and one-half times denser in *P. vagans* than in *P. conglutinatum* n. sp., and skeletal elements are finer (*P. vagans* laminae 0.05–0.07 mm, pillars 0.05–0.10 mm thick). Pillar thickness of *P. juxi* is comparable to *P. conglutinatum* n. sp., and ranges of laminar thicknesses overlap (0.10–0.20 mm vs. 0.14–0.28 mm); spacing of skeletal elements is somewhat closer in *P. juxi* (4 to 6 laminae, 6 to 8 pillars in 2 mm).

The most noteworthy feature of *Pseudoactinodictyon conglutinatum* n. sp. is the arrangement of successive laminae, either fused to form thick compound laminae, or separated by a gap of irregular thickness. Such an arrangement suggests a growth pattern in which each successive unit, composed of thin upper and lower laminae joined by pillars, is separated by an interruption in growth. The succeeding thin lower lamina is lain atop the upper lamina of the previous growth unit, and either "welded" to it, or remains separated by a gap. This unusual growth pattern is also known in (and characteristic of) the genera *Simplexodictyon* (formerly *Diplostroma*; *cf.* Nestor, 1976; Stearn, 1991) and *Nuratodictyon* (known from only one specimen; Lessovaya, 1972, Stearn, 1980). The significance of such gaps between the laminae is further discussed by Stearn and Pickett (1994). Mori (1968) first recognized that the "split" laminae of *Simplexodictyon* indicate pauses in growth, the gaps being devoid of skeletal elements and often incorporating trapped sediment or encrusting organisms. No trapped sediment or encrusting organisms are present within the interlaminar gaps of *Pseudoactinodictyon conglutinatum* n. sp. Another difference from *Simplexodictyon* is that in this latter genus divergent laminae are much more common than fused laminae, but in *P. conglutinatum* n. sp. gaps are distributed sporadically: in the paratype (GSC 108871) gaps are much rarer than in the holotype (GSC 109970).

Stearn (1980, 1991) proposed the Family Simplexodictyidae (formerly Diplostromatidae) for species demonstrating the interrupted growth pattern diagnostic of *Simplexodictyon* and *Nuratodictyon*. Recognition of this unusual growth pattern outside these two genera, as is the case here, may require reevaluation or some redefinition of the Family Simplexodictyidae.

Simplexodictyon grandiosum Lessovaya, 1970 from the upper Emsian (*Favosites regularissimus* Zone) of Uzbekistan (Lessovaya, 1970), shows certain similarities to *Pseudoactinodictyon conglutinatum* n. sp. from Ellesmere Island, and may be related. *Simplexodictyon grandiosum* is very robustly built (laminae and pillar spacings 4 to 5 per 2 mm), and has thick (0.2–0.4 mm), "bipartite" laminae with an axial light-coloured zone (Lessovaya, 1970; p. 87). Lessovaya's description and illustrations do not however indicate any divergence or gaps between the compound or "bipartite" laminae; the pillars of *S. grandiosum* are thick, simple and spool-shaped. It appears unlikely that *Pseudoactinodictyon conglutinatum* n. sp. and *Simplexodictyon grandiosum* are the same species, but that the central Asian species may be another Lower Devonian form of *Pseudoactinodictyon,* allied to *Pseudoactinodictyon conglutinatum* n. sp. An earlier suggestion by Stearn (1991) that *Simplexodictyon grandiosum* should be reassigned to the genus *Petridiostroma* is probably incorrect.

Etymology.—From the Latin *conglutinatus,* bound or glued together; describes the fused twin laminae.

Occurrence.—Blue Fiord Formation, Ellesmere Island; formation type section, upper member, from a unit lying 200–400 m below the top of the formation (two type specimens); upper Emsian (*inversus-serotinus* Zones). Bird Fiord Formation, near base of formation; Bird Fiord, Ellesmere Island (one specimen); uppermost Emsian/basal Eifelian (undifferentiated *patulus* Zone).

Genus **SCHISTODICTYON** Lessovaya, 1970

Type species.—*Schistodictyon posterius* Lessovaya, 1970.

Schistodictyon? sp.

Plate 7, figures 5,6

Description.—Skeleton apparently laminar.

Vertical section: Laminae thin 0.03–0.04 mm, regular, continuous, flat or gently undulate; spacing regular, 7 to 10 per 2 mm, average 8.6 (n=10); microstructure compact, locally weakly transversely fibrous. Pillars very variable: simple spool-shaped (44%), upward-thickening to meet overlying lamina (28%), upward-bifurcating Y-or V-shape (26%); doubly upward-dividing (2%) (n=100); dominantly vertical, but commonly inclined; spaced 7 to 9 per 2 mm, average 7.7 (n=10); thickness 0.04–0.06 mm, up to 0.10 mm at junction with overlying lamina; rarely superposed.

Tangential section: Laminae form thin, diffuse, meandering bands. Pillars dominantly simple dots 0.04–0.08 mm diameter, may be vermiform or linked toward laminae; irregular rings rare. Dissepiments rare. Astrorhizae absent.

Material.—A single specimen, GSC 108872. Well preserved.

Discussion.—This single specimen is questionably assigned to the genus *Schistodictyon* on the basis of its Y-and V-shaped pillars (a few of which are doubly bifurcating). Ideally, *Schistodictyon* is characterised by a predominance of bifurcating pillars (Stearn, 1991), as demonstrated by *S. papillatum* (Parks) (*cf.* Stearn, 1991, fig. 2.2). In vertical sections of *Schistodictyon*? sp. from Ellesmere Island, only about one-quarter of the pillars are bifurcating; about one-half are simple rods and the remainder are intermediate in nature (*i.e.*, upward-thickening). Specimens such as this, which show characteristics intermediate between *Schistodictyon* and related genera such as *Petridiostroma* and *Anostylostroma*, are not unusual. Because the true morphological range of this species cannot be understood from a single specimen, the generic assignment must remain equivocal.

Vertical sections of *Schistodictyon*? sp. are similar to those of *Petridiostroma* sp. (also from the Blue Fiord Formation, Ellesmere Island). The main difference is the proportion of bifurcating pillars (which are rare in *Petridiostroma* sp.). Tangential sections more clearly show this distinction, but the possibility cannot be dismissed that the single specimens separately assigned to *Schistodictyon*? sp. and *Petridiostroma* sp. are conspecific. Many more specimens are needed before these problems can be meaningfully resolved.

Specimens from the Emsian of eastern Australia assigned to *Schistodictyon* sp. by Webby and Zhen (1993) are quite similar to the Blue Fiord specimen, but again too little material is available from which to draw firm conclusions.

Occurrence.—Blue Fiord Formation, lower 100 m; vicinity type section; lower Emsian (*dehiscens* Zone).

Order **STROMATOPORELLIDA** Stearn, 1980

Family **STICTOSTROMATIDAE** Khalfina and Yavorsky, 1973

Genus **STICTOSTROMA** Parks, 1936

Type species.—*Stictostroma gorriense* Stearn, 1995.

Stictostroma gorriense Stearn, 1995a

Plate 8, figures 1–5

non *Stromatopora mammillata* Nicholson, 1873, p. 94, pl. 4, fig. 4.

Stictostroma mammillatum (Nicholson). Parks, 1936, p. 78–81, pl. 14, figs. 3–6.

Stictostroma mamilliferum Galloway and St. Jean, 1957, p. 125–127, pl. 6, figs. 4a,b; Galloway, 1957, pl. 31, fig. 6, pl. 33, fig. 9; St. Jean, 1962, p. 188–189, pl. 31, figs. 1–5; Fagerstrom, 1982, p. 40–41, pl. 8, figs. 6,7; Prosh and Stearn, 1993, figs. 3c, 3d.

Stictostroma mccannelli Fagerstrom, 1961, p. 7, pl. 2, figs. 7–9; 1982, p. 40–41.

Stictostroma gorriense Stearn, 1995a, p. 26, figs. 1.6, 1.7, 2.5, 2.6; 1995b, p. 1–3.

Description.—Skeleton weakly domical to thick-laminar with ragged edge; rarely encrusting or intergrown. Surfaces bearing abundant, small, very regularly spaced mamelons, ca. 1 mm high, 1–2 mm diameter, 4–5 mm center-to-center distance. Latilaminae moderately well developed, 2–4 mm thick.

Vertical section: laminae continuous, flat or very gently undulate, consistently parallel; regularly spaced, commonly 13 to 15 per 2 mm, specimens GSC 108873 average 14.3 range 12 to 17, GSC 108177 average 14.2 range 12 to 16, GSC 108176 average 14.0 range 13 to 15, GSC 108874 average 13.8 range 12 to 15 (all n=10); thickness 0.03–0.06 mm, commonly 0.04–0.05 mm; microstructure ordinicellular, transverse tubules and intervening skeletal material both about 10–15 μm wide, grading locally to tripartite or with median row of cellules; diagenetically altered laminae tripartite, with median pale band 0.02–0.04 mm thick and dark exterior bands 0.01 mm thick, vaguely transversely fibrous. Pillars stout, spool-shaped, 0.04–0.08 mm thick, thickening and merging into laminae; very rarely formed by up-arching and merger of lower lamina (in the manner of *Stromatoporella*); irregularly offset between successive laminae, rarely superposed; spaced irregularly 7 to 12 per 2 mm, specimens GSC 108873 average 9.2 range 7 to 11 (n=20), GSC 108177 average 9.6 range 8 to 11 (n=10), GSC 108176 average 9.7 range 9 to 11 (n=10), GSC 108874 average 10.1 range 9 to 12 (n=10); locally absent for lengths up to 1 mm; microstructure poorly preserved, generally suggesting cellules or vertically-aligned tubules. Dissepiments broadly convex, very thin, 5–10 μm, commonly occupying uppermost portion of galleries; easily lost diagenetically, probably originally common. Mamelons variably and only sparingly evident (despite prominence on exposed surfaces), apparent in some specimens and not in others; mostly shallow, vertically impersistent, with no or very weak astrorhizal canals; less commonly may be vertically persistent up to 5 mm height, with poorly developed astrorhizae, central canal 0.15 mm wide. Intergrown organisms (corals, algae) common.

Tangential section: laminae thick diffuse bands. Open gallery space generally comprises less than half total area. Pillars subcircular, isolated, numerous, crowded, 0.04–0.10 mm diameter; ring-pillars absent; microstructure cellular (sectioned transverse tubules), cellule diameter 10–15 μm, but fine-structure only very rarely preserved, commonly compact. Astrorhizae comprise few, short, poorly-defined canals, 0.10 mm diameter; about half of all mamelon centers without astrorhizae.

Material.—Eight specimens; one complete skeleton, 7 partial (2 of which are encrusting). Moderately well to well preserved. Hypotypes GSC 108873 to 108875, 108176, 108177. Other specimens listed in Appendix 3.

Discussion.—*Stictostroma gorriense* has been widely recognized from southern Ontario; the most thorough synonymy to date was provided by Fagerstrom (1982,

Table 1.—Comparative measurements of *Stictostroma gorriense* Stearn.

Species	*lamin. spac'g/ 2 mm**	*lamin. thick. mm**	*pillar spac'g/ 2 mm*	*pillar thick. mm*	*mam. h'ght mm*	*mam. diam. mm*	*mam. spac'g. mm c-c*	*astrorhizae*	*lati. spac'g mm*
Blue Fiord specimens *S. gorriense*	13–15 (12–17)	.04–.05 (.03–.06)	7–12	.04–.08	1	1–2	4–5	some, poor	2–4
Galloway and St. Jean (1957) *S. mamilliferum*	11–13	.03–.06	4–7	.02–.2	2	3–7	7–12	none	1–2
Fagerstrom (1982) as *S. mamilliferum*	9–14		+10					variable	1–3
Fagerstrom 1961 as *S. mccannelli* = *S. mamilliferum*	11–13	0.1	8–12	.01–.2	.5–2	4–6	6–8	short	1–3
Parks (1936) as *S. mammillatum*	12	.04	±10	.02–.16			8	none	

* Average spacing and range ( ) are given.

Abbreviations: *lamin.*—laminar, *spac'g*—spacing, *thick.*—thickness, *mam.*—mamelon, *h'ght*—height, *diam.*—diameter, *mam. spac'g* mm c-c—mamelon spacing millimeters center-to-center, *lati.*—latilaminar.

p.40). Major morphologic measurements of previously described occurrences and of the Blue Fiord specimens are shown in Table 1. The Blue Fiord specimens fall within the specific range of variation for most criteria, with the spacing of their laminae falling at the closely-spaced extreme. Narrowly spaced laminae distinguish *S. gorriense* from the closely related species *S. problematicum* and *S. anomalum* (see Fagerstrom, 1982). As is apparent in Table 1, there is considerable variation in morphometric ranges between described occurrences. Some of this variation may be due to geographic variability, but most, as noted by Fagerstrom (1982), is artifactual, due to excessively small sample sizes.

A feature of considerable importance is the development of numerous, close-set mamelons. In contrast to previous descriptions, the mamelons of Blue Fiord *S. gorriense* are smaller and more crowded, but otherwise similar in terms of form and arrangement. Although numerous (on exposed growth surfaces), the mamelons of Blue Fiord *S. gorriense* are narrow and mostly impersistent, so that their expression in vertical thin-section is often severely muted. Development of astrorhizae is similarly highly variable. Although Galloway and St. Jean (1957) diagnosed *S. mamilliferum* = *gorriense* as without astrorhizae, Fagerstrom's (1982) analysis of a large sampling revealed weak astrorhizae in some specimens. The same irregular development of astrorhizae occurs in the Blue Fiord specimens, roughly half with and half without astrorhizae.

The Arctic occurrence of this species is of biostratigraphic significance, relating the Blue Fiord Formation (Emsian) to North American midcontinent occurrences of uncertain chronostratigraphy. *Stictostroma gorriense* has been recorded from the lower Detroit River Group of southern Ontario (Parks, 1936; Galloway and St. Jean, 1957; Fagerstrom, 1961, 1982). A correlation using this species and *Stromatoporella perannulata* suggests that the Detroit River Group is fully Emsian in age (Prosh and Stearn, 1993).

Occurrence.—Blue Fiord Formation, Ellesmere Island; lower member, vicinity type section (six specimens), lower Emsian (*dehiscens* Zone); upper member, Vendom Fiord (two specimens), upper Emsian (*inversus–serotinus* Zones).

Stictostroma? nunavutense, new species
Plate 9, figures 1–5

Diagnosis.—Thick, regularly spaced extensive laminae of microtubulate to ordinicellular microstructure with two to three internal tubules within thickness of lamina. Vertical elements rarely irregular post-pillars, commonly coenosteles, thick. Astrorhizal systems diffuse, pervasive, interrupting the lateral regularity of the structure.

Description.—Skeleton hemispherical to irregular, up to 10 cm diameter; surface rough, without mamelons or visible astrorhizae. Latilaminae crude, irregular, 0.5–1.0 cm thick.

Vertical section: Laminae thick 0.15–0.20 mm, gently undulate to irregular; variably continuous, locally interrupted by abundant foramina; spacing very regular, 6 to 8 per 2 mm, specimen GSC 108876 (holotype) average 7.0 range 6 to 8, GSC 108877 average 6.9 range 6 to 8 (each n=10). Laminar microstructure microtubulate to ordinicellular; lateral tubules commonly 2 to 3 within the thickness of laminae, 0.02 mm wide; microstructure commonly diagenetically altered to transversely fibrous or compact. Pillars and coenosteles variable in form; most commonly as thick as laminae, 0.10–0.20 mm; stout, uniformly thick or slightly expanding to meet overlying lamina; randomly offset, locally superposed over three or four laminae; thin pillars fewer, rod-shaped, as thin as 0.05 mm;

microstructure of thick pillars tubulate to fibrous, of thin pillars compact. Galleries variable, commonly circular 0.10–0.15 mm diameter, some laterally elongate, vermicular. Locally where interrupted by astrorhizal systems, macrostructural framework tends toward amalgamate. Dissepiments rare, very fine, 0.01 mm thick. Astrorhizae vague, indicated only by upward-doming of laminae, interruption of laminae by vertical canals, and zones of disordered lateral canals 0.15 mm diameter merging intimately with galleries.

Tangential section: Thick, labyrinthine network with little open gallery space. Dominantly closed labyrinthine network of coenosteles 0.15–0.20 mm across; isolated pillars subordinate, either subcircular dots (post-pillars) or short vermiform segments 0.10–0.15 mm diameter. Microstructure clotted, grading to irregularly tubulate in thick labyrinthine elements and laminae. Astrorhizae common, defined by short, branching astrorhizal paths between coenosteles, weakly ordered radial zones of short irregular canals 0.15 mm diameter, grading rapidly into labyrinthine gallery space. Astrorhizal centres spaced about 6 mm apart.

Material.—Six specimens, ranging from poorly to well preserved. Holotype GSC 108876; paratypes GSC 108877 and 108878. See Appendix 3 for other specimens.

Discussion.—*Stictostroma*? *nunavutense* n. sp. is characterized by thick, regularly spaced laminae, generally equally thick pillars that are either offset or irregularly superposed, and tubulate microstructure. It is an unusual new species not readily assignable to known genera. Compared to most species of *Stictostroma,* the skeletal elements of *S.*? *nunavutense* are much thicker and less regularly arranged. It is tentatively assigned to *Stictostroma* on the basis of its continuous laminae, non-superposed pillars, and similar microstructure. Numerous stromatoporellid species (of *Stromatoporella, Stictostroma,* and *Clathrocoilona*) have previously been described as microtubulate (*e.g.,* Birkhead, 1967; Zukalová, 1971).

The astrorhizae of *Stictostroma*? *nunavutense* n. sp. are unusually diffuse and apparently pervasive. They do not form discrete structures, but rather considerably modify the structural architecture of the stromatoporoid at intervals; in this indirect way they are diagnostic. In vertical section the astrorhizae *per se* are difficult to locate, defined by zones of vertically elongate canals that intimately merge into the gallery network. In tangential section they are more easily identified, forming clusters of canals that again merge radially into galleries. Tangential sections indicate the astrorhizae are abundant and very closely spaced (about 6 mm apart). In vertical section, therefore, the astrorhizae may simply appear as zones where complex galleries occur and laminae may be discontinuous, and the skeleton itself may verge on an amalgamate structure. The "background" architecture of the stromatoporoid, as it were, is continuous thick laminae, dominantly circular galleries; the astrorhizal systems are so integrated into the skeleton, however, that this unmodified structure occurs in only about half the vertical view.

All specimens of this species show variably irregular growth form, and none of the specimens is uniquely composed of this species. All show varying degrees of intergrowth with other stromatoporoid species, most commonly *Gerronostroma septentrionalis* n. sp. and *Stictostroma gorriense* Stearn, 1995.

Etymology.—For Nunavut, the territory of the eastern Canadian Arctic; in the language of the Inuit, "land of the people."

Occurrence.—Blue Fiord Formation, lower member, lower 100 m; Ellesmere Island, Eids Fiord; lower Emsian (*dehiscens* Zone).

Genus **STROMATOPORELLA** Nicholson, 1886

Type species.—*Stromatoporella granulata* Nicholson, 1886

Stromatoporella perannulata
Galloway and St. Jean, 1957
Plate 10, figures 1,2

Stromatoporella cellulosa Parks, 1936, p. 108–110, pl. 4, figs. 6,7; non *Clathrodictyon cellulosum* Nicholson and Murie, 1878, p. 221, pl. 2, figs. 6–10.

Stictostroma eriense Parks. Lecompte, 1951, pl. XX, figs. 2, 2a, 2b.

Stromatoporella perannulata Galloway and St. Jean, 1957, p. 142–144, pl. 9, figs. 3a,b; St. Jean, 1986, p. 1043–1045, figs. 5.4–5.6; Prosh and Stearn, 1993, Figs. 3a,3b.

Stromatoporella eriensis (Parks). Galloway and St. Jean, 1957, p.145–147, pl.10, figs. 2a,b.

Stromatoporella perannulata(?) Fagerstrom, 1982, p. 38–39, pl. 7, figs. 2–4.

Stromatoporella eriense(?) (Parks). Fagerstrom, 1982, p. 39, pl. 7, fig. 5.

Description.—Skeleton laminar, thick, only gently undulate. Surface bears few small low-relief mamelons, 0.1 mm high, 0.2 mm diameter, irregularly spaced 1–2 cm apart, without astrorhizae; surface visibly fine granular. Latilaminae moderately to poorly developed, up to 1.0 cm thick.

Vertical section: Laminae continuous, generally consistently parallel, rarely merging laterally, gently to moderately undulant; extremely crenulate on a fine-scale; very thin 0.02–0.04 mm, but commonly thickened and obfuscated diagenetically; regularly spaced, 7 to 10 per 2 mm, specimens GSC 108175 average 8.5 range 8 to 10, GSC 108879 average 7.7 range 7 to 8, GSC 108880 average 7.7 range 7 to 9 (all n=10); microstructure finely transversely porous or fibrous, locally altered to compact, not tripartite. Pillars either rings or simple posts, continuous lateral count of 100 complete pillars (GSC 108175) 51% rings 49% posts; rings extend fully to overlying lamina, central lumen 0.03–0.06 mm across, walls as laminae 0.02–0.04 mm thick; posts simple, may very gently thicken at laminae, 0.02–0.05 mm thick; no pattern of distribution rings and posts, although either may cluster 3 or 4 consecutive, certain interlaminar spaces may display more of one than another; never superposed, fairly consistently offset; spaced 6 to 9 per 2 mm, specimens GSC 108175 average 7.3 range 6 to 9, GSC 108879 average 7.3 range 6 to 8, GSC 108880 average 7.4 range 6 to 9 (all n=10); microstructure of rings transversely fibrous, continuous with laminae, of posts vaguely fibrous or compact. Galleries subequally elongate-rectangular or subcircular; subcircular where ring-pillars abundant, locally forming short bead-like chains; elongate galleries up to 2 mm long locally present where pillars absent. Dissepiments only locally abundant, very broadly convex, thin 0.02 mm. Mamelon columns rare (present only GSC 108175), up to 1.5 cm high; one thin section (of GSC 108175) preserves short segment (2.0 mm) central astrorhizal canal, without lateral tributaries; astrorhizae otherwise absent. One specimen (110-236) with abundant commensal corals.

Tangential section: Laminae forming meandering thin bands or lines, highly scalloped (linked partial-ring pillars) or confluent with ring-pillars. Ring-pillars abundant, either half total pillars (GSC 108175) or fewer than half (GSC 108879, 108880); most common within or adjacent to laminae, less commonly within interlaminar spaces; wall thickness 0.02–0.04 mm, central lumen 0.04–0.12 mm diameter; roughly 0.10–0.12 mm apart center-to-center; microstructure transversely porous or fibrous. Post pillars small, irregular dots, 0.03–0.08 mm diameter; many intergrading shapes between ring and post pillars. Mamelon columns marked by sectioned laminae forming bull's-eyes, roughly 1–2 mm apart center-to-center; no astrorhizae.

Material.—Six specimens, ranging from poorly to exceptionally well preserved. Hypotypes GSC 108175, GSC 108879, GSC 108880. Other specimens listed in Appendix 3.

Discussion.—*Stromatoporella perannulata* is widely documented from the North American midcontinent. The type specimens of Galloway and St. Jean (1957) come from the Jeffersonville Limestone near Louisville, Kentucky. Many more specimens are recorded from southern Ontario and vicinity. Fagerstrom (1982) listed many occurrences from the Formosa Reef Limestone (Amherstburg Formation) and the Detroit River Group of Ontario, and from the Columbus Limestone near Marblehead, Ohio. St. Jean (1986) described *S. perannulata* from the Port Colborne area (Niagara Peninsula) of Ontario, in rocks of uncertain assignment (Bois Blanc Formation or lower Onondaga Limestone). The Port Colborne specimens of St. Jean (1986) are strikingly similar to those from the Blue Fiord Formation (compare Plate 10, figures 1 and 2 herein to figs. 5.4 to 5.6 of St. Jean, 1986).

Stromatoporella eriensis (Parks) does not objectively differ from *S. perannulata,* and most references to *S. eriensis* should be transferred to *S. perannulata.* As noted by Fagerstrom (1982), the presumed difference, that *S. perannulata* has mamelons and *S. eriensis* has none, is untenable. Larger collections of specimens (of Fagerstrom, 1982, and herein) demonstrate variable development of mamelons in *S. perannulata.* In given specimens mamelons may be weakly developed or locally absent, and therefore present in some thin-sections and absent in others. The synonymy herein includes all references to *Stromatoporella eriensis* exclusive of the type specimens of Parks, 1936 (originally referred to *Stictostroma eriense*). Examination of Parks' types reveals specimens unlike *S. perannulata.* Parks' holotype 2610.D (ROM 13190) shows more widely spaced laminae (6 to 8 per 2 mm) that are at least twice as thick (0.05–0.10 mm) as those of *S. perannulata.* Also the strong crenulation of laminae into the pillars of *S. perannulata* is poorly developed in Parks' types (2601.D, 2602.D, 2603.D). Although assignable to *Stromatoporella,* Parks' types represent a species other than *S. perannulata.* The species *Stromatoporella eriensis* (Parks) therefore appears to be uniquely confined to Parks' (1936) types, but all subsequent references to *S. eriensis* belong to *S. perannulata.*

In the Arctic, *S. perannulata* is confined to the Emsian Blue Fiord Formation (*dehiscens* to *inversus* Zones). The presence of *S. perannulata* and *Stictostroma gorriense* in both the Blue Fiord Formation and the Detroit River Group of Ontario suggests these units are time-correlative, *i.e.,* the Detroit River Group is Emsian (Prosh and Stearn, 1993).

Occurrence.—Blue Fiord Formation, Ellesmere Island; lower member, Eids Fiord (one specimen), Sör Fiord (2 specimens), Vendom Fiord (one specimen), lower Emsian (*dehiscens–gronbergi* Zones); platformal dolomitic facies, Goose Fiord, Muskox Fiord (one specimen each), mid-Emsian (*inversus* Zone).

Genus **CLATHROCOILONA** Yavorsky, 1931

Type species.—*Clathrodocoilona abeona* Yavorsky, 1931.

Clathrocoilona Yavorsky, 1931, p. 1394–1395, 1407; Kossareva, 1976, p.21; Stock, 1982, p. 670–673; synonymies therein.

Discussion.—Yavorsky's original diagnosis of the genus, based uniquely on the type *Clathrocoilona abeona,* stressed strictly macrostructural details, principally the abundant astrorhizal foramina, thick continuous laminae, and non-superposed pillars. He characterized the microstructure as compact, but noted the presence of a white median line in the laminae. Subsequent authors placed greater emphasis on microstructure, and differing assessments of the composition of *Clathrocoilona* resulted in divergent suprageneric assignments. Galloway (1957) and Galloway and St. Jean (1957) considered *Clathrocoilona* to be "coarsely maculate" (although with thick, tripartite laminae), and hence assigned *Clathrocoilona* to the Stromatoporidae. Although Lecompte (1951) did not recognize *Clathrocoilona* as valid, many species he placed in *Stromatoporella* were later reassigned to *Clathrocoilona* (Flügel and Flügel-Kahler, 1968; Kossareva, 1976). Still, Lecompte's emphasis on the tripartite laminae of these species helped influence subsequent workers to include *Clathrocoilona* with the Stromatoporellidae (Zukalova, 1971) or Stromatoporellida (Stearn, 1980). Most recently, Stock (1982) placed *Clathrocoilona* in the Stromatoporidae, interpreting its microstructure as "originally microreticulate or melanospheric, but may be altered to compact" (p. 671), and noting the common occurrence of tripartite laminae.

Kossareva (1976) advanced understanding of *Clathrocoilona* with a redescription of the genus and a detailed microstructural analysis of Yavorsky's types (regrettably unillustrated). Kossareva described the laminae of *Clathrocoilona* as composite, made up of 2 to 4 microlaminae joined by micropillars. In Kossareva's concept the multilayered laminae appear to bear 1 to 3 light median bands, in places preserving the micropillars and appearing cellular, elsewhere appearing continuous or hollow. Commonly the tissue is permeated by small pores. For much of the skeleton, Kossareva described the elements as having a "felted appearance", implying a disordered microstructural network, producing a tangle of microlaminae and light bands.

The foregoing brief history illustrates the variety of suprageneric assignments proposed for *Clathrocoilona,* and how interpretation of its complex microstructure has influenced its assignment. Similarly, *Clathrocoilona vexata* n. sp. (described below) demonstrates a bewildering variety of microstructures, that has prompted one of us (ECP) to interpret them as diagenetic modifications of microreticulation (hence favoring assignment to Order Syringostromatida), the other author (CWS) as variability in the original skeletal microstructure. Owing to these uncertainties, and to the subjectivity of interpreting microstructure, we retain *Clathrocoilona* in the Order Stromatoporellida.

Clathrocoilona vexata, new species

Plate 10, figures 3, 4; Plate 11, figures 1–8;
Plate 12, figures 1,2

Clathrocoilona cf. *C. saginata* Lecompte. Stearn, 1983, p. 549, 551, figs. 5G, 5H.

Diagnosis.—Skeletal elements in alternately thick and thin successive phases; very closely spaced laminae and pillars.

Description.—Skeletal form variable, commonly thin encrusting, some irregular, rarely small hemispheres. Surface irregular; small mamelons abundant, astrorhizae imperceptible. Latilaminae 2–3 mm thick.

Vertical section: Alternating zones or phases of thin and thick skeletal elements (laminae and pillars). Laminae very irregular, undulate, discontinuous, interrupted by abundant foramina and coalescing laterally; sharply inflected into shallow mamelons confined to single latilamina; spaced 9 to 14 per 2 mm, holotype GSC 108881 average 10.7 range 9 to 12, paratype GSC 108882 average 13.0 range 11 to 14 (each n=10); thick laminae 0.06–0.15 mm; thin laminae as thin as 0.02 mm; commonly thick laminae (and pillars) at base latilamina, grade to thin at top. Pillars spool-shaped, thick 0.05–0.14 mm, or thin to 0.03 mm; commonly randomly offset between successive laminae, a few superposed over 2 to 4 laminae; spaced 8 to 13 per 2 mm, holotype GSC 108881 average 9.3 range 8 to 11, paratype GSC 108882 average 11.4 range 9 to 13 (each n=10); locally absent. Microstructure complex, highly variable; porous/cellular, fibrous, vermiculated, or compact; pores/cellules scattered, subspherical or vertically elongated, 15–20 μm diameter, where juxtaposed intervening microelements 5–15 μm thick. Astrorhizae poorly formed; rare short irregular vertical canals 0.10 mm diameter; subcircular or ovoid foramina ubiquitous, 0.3–0.6 mm lateral diameter. Dissepiments common, abundant in areas of skeletal repair; broadly convex, thin 0.01 mm. Included organisms (gastropods, brachiopods, ostracodes, worm tubes) common.

Tangential section: Laminae dense meandriform bands, discontinuous. Pillars isolated dots 0.04–0.10 mm diameter, or short thick 0.08–0.10 mm gently curved vermiform strands. In holotype (GSC 108881) about half visible area free laminae and pillars (thin element zones); remainder dense, clotted, amalgamate, little open gallery space (thick element zones). Astrorhizae common, widely dispersed; form rare irregularly branched aggregates; main/axial canals 0.25–0.30 mm diameter, secondary canals commonly 0.08–0.15 mm diameter; tabulae present, poorly preserved. Microstructure porous/tubulate, vermiculated, fibrous, irregularly melanospheric, or compact; pores scattered, locally clustered, circular to oval, 10–20 μm diameter, where section oblique plunge into shallow tubules.

Material.—Nine specimens, four of them well preserved. Holotype GSC 108881, paratypes GSC 108882, 108883. Other specimens listed in Appendix 3.

Discussion.—Thirty to 40 species of *Clathrocoilona* are previously known; the tally is imprecise because some species are probably redundant, others misassigned to genera such as *Stromatoporella.* The characteristic, extreme structural variability of *Clathrocoilona* species makes comparison and identification difficult. *Clathrocoilona vexata* n. sp. is distinguished by very narrowly spaced skeletal elements, 9 to 14 laminae and 8 to 13 pillars per 2 mm; most *Clathrocoilona* species average around 5 to 6 laminae and pillars per 2 mm. Only *Clathrocoilona saginata* (Lecompte, 1951) (Frasnian; Belgium) displays comparable spacing, with 9 to 14 laminae and 6 to 10 pillars per 2 mm. *C. saginata* differs from *C. vexata* n. sp. in its more regularly arranged laminae, fewer astrorhizal foramina, and much more pronounced and persistent mamelons. This new species was earlier referred to *Clathrocoilona* cf. *C. saginata* by Stearn (1983).

Another distinctive feature of *C. vexata* n. sp. is the alternation of zones of thin versus thick skeletal elements (laminae and pillars). Similar thickness alternation is also exhibited by *Clathrocoilona solida* Yavorsky, 1955, *C. solida* (Hall and Whitfield, 1873, redescribed by Stock, 1984) and *C. saginata* (Lecompte), and to a lesser degree by *C. crassitexta* (Lecompte, 1951), *C. crassum* (Yavorsky, 1963), *C. obliterata* (Lecompte, 1951), and *C. spissa* (Lecompte, 1951) (but strongly present in *C. spissa* of Zukalová, 1971). In *C. vexata* n. sp. and these other species the thickness alternation is pronounced, yet similar variation can be found in many, if not most species of *Clathrocoilona.*

Areas of good preservation in tangential sections of *C. vexata* n. sp. show small circular voids 10–20 μm across and distributed randomly (Pl. 11, fig. 1). One of us (ECP) postulates that these, among other criteria, are evidence that the microstructure is irregularly microreticulate, a microstructure described by Stock (1989) as akosmoreticulate. The other (CWS) would call this microstructure largely cellular, but the distinction between the two is mostly semantic. The voids or pores in tangential section would then be described by the former as microgalleries and by the latter as cellules. This porous skeletal material does not appear to have been secreted uniformly but originally was separated by skeletal elements of compact tissue. A much wider range of microstructures occurs, however, in *C. vexata* n. sp. This range (from cellular to melanospheric to tubulate to ordinicellular to tripartite to fibrous to compact) can be interpreted as caused by: 1) diagenetic filling of the voids that define the microstructure, or 2) to an original broad range of secreted skeletal material, or 3) to a combination of both.

Vertical sections (Pl. 11, figs. 2, 3) may show vertically elongate or tubular voids separated by similar fine skeletal tissue that would be called micropillars by one of us (ECP). Fine horizontal elements cross these voids, but whether they are solid plates (microlaminae) or rods (microcolliculi) is uncertain. Certain states interpreted as diagenetic by ECP exhibit a tangled mass of tubular voids and intervening skeletal material (Pl. 11, fig. 4). This is the microstructure recognized by Kossareva (1976) as "felted" (referred to as vermiculated herein). Further diagenetic alteration is postulated to result in coarsely fibrous microstructure and ultimately compact skeletal material (Pl. 11, fig. 5). In another diagenetic state, the vermiculated microstructure becomes "blocky" and in tangential section appears to be composed of melanospheres (Pl. 11, figs. 6, 7). In the opinion of CWS these myriad microstructures may not all be derived from originally akosmoreticulate microstructure, but indicate that the skeletal material as originally secreted may have locally been cellular or ordinicellular, locally compact or fibrous, and locally tubulate.

Very locally the laminae of this species are tripartite or ordinicellular (Pl. 11, fig. 8). In *C. vexata* n. sp. cellular or akosmoreticulate microstructure only develops in the skeletal elements thicker than 40 μm. Only laminae of about this thickness or greater can accommodate a single row of cellules/microgalleries 20 μm high. Where the slim partitions between the cellules are not preserved, the laminae appear to be tripartite. In the opinion of ECP, this local development of tripartite structure is fortuitous and a chance result of microreticular alignment, and therefore not analagous to the tripartite laminae of the Stromatoporellida.

A wide range of microstructures has been ascribed to other species of *Clathrocoilona.* Galloway (1957) and Galloway and St. Jean (1957) described the genus as coarsely maculate with thick tripartite laminae. The tangential section of *C. fibrosa* (Galloway and St. Jean, 1957; pl. 22, fig. 3b) shows a porous microstructure similar to that of *C. vexata* n. sp. The "coarse irregular maculae" of Galloway and St. Jean are areas of altered tubulate microstructure. Kossareva's (1976) description of *C. abeona* indicates a wide range of microstructures as noted above. Kossareva described laminae as cellular or joined by micropillars, apparently similar to the ordinicellular laminae of *C. vexata* n.

sp. Zukalová (1971) described microstructures as finely tubulate or cellular/porous; her illustrations resemble the tubulate tissue of *C. vexata* n. sp. Tubulate microstructures are also noted by Stock (1982) in *C. involuta* Stock, 1982 and Birkhead (1967) in *C. subclathrata* and in species he assigned to *Stromatoporella* (eg., *S. indubia* Birkhead), which should be transferred to *Clathrocoilona.*

The microstructure of *C. vexata* n. sp. suggests that the genus includes species with a very broad range of microstructures. One of us (ECP) attributes this range to diagenetic modification of an originally pervasive akosmoreticulate microstructure; the other (CWS) attributes it to variability in the original pattern of skeletal secretion. In recognition of this variability (regardless of origin), we both of us agree that microstructure should not be used as a taxonomic criterion in assigning species to *Clathrocoilona.* The example of the range of microstructures found in *C. vexata* n. sp. can be used as a guide in interpreting the variety of skeletal material that may occur in other species of this genus. The macrostructural criteria on which *Clathrocoilona* is defined are fully satisfactory in assigning species.

Etymology.—Latin *vexata,* vexacious or troublesome; referring to the confounding structural variability characteristic of species belonging to this genus.

Occurrence.—Blue Fiord Formation, lower member, Ellesmere Island; vicinity type section (seven specimens), Vendom Fiord (two specimens); lower Emsian (*dehiscens* Zone).

Family **HERMATOSTROMATIDAE**
Nestor, 1964

Genus **TRUPETOSTROMA** Parks, 1936

Type species.—*Trupetostroma warreni* Parks, 1936.

Trupetostroma sp.
Plate 12, figures 3,4

Description.—Skeleton laminar, highly undulate. Surface not preserved, but apparently bearing large, broad mamelons.

Vertical section: Laminae thick, tripartite, continuous, broadly undulate, consistently parallel; aggregate thickness 0.10–0.16 mm, consisting of median clear (hollow) zone 0.04–0.06 mm thick, bordered above and below by microlaminae 0.03–0.05 mm thick, exterior locally thickened; spaced very regularly, 5 to 6 laminae per 2 mm, average 5.5 (n=10); rarely interrupted by small foramina about 0.1 mm across; a few (generally thicker) laminae display third median microlamina over limited lengths. Pillars commonly spool-shaped, thick 0.06–0.15 mm (commonly 0.08–0.10 mm), spreading and thickening broadly to meet laminae; mostly randomly offset between successive laminae, locally superposed over 2 to 4 laminae; spaced variably, 5 to 8 per 2 mm average 6.3 (n=20), locally missing for lengths up to 0.1 cm; skeletal material generally solid (?compact microstructure), but a few pillars appear to be hollow (as laminae), vaguely vacuolate, or as if composed of vertical fibrils. Dissepiments common, not abundant, small, shallowly convex, very thin 0.01 mm, probably mostly removed by diagenesis; commonly bridging laminar foramina, towards mamelon axes, or within anomalously large galleries. Mamelons large, broad, vertically persistent; indicated in part by pillars crowding, thickening and becoming more strongly superposed; astrorhizal canals undefined. Microstructure ambiguous (due to poor preservation), probably compact. Rare, small vacuoles may occur at pillar-lamina junctions, or at thickened regions of external microlaminae.

Tangential section: Mamelons prominent, marked by large, well-defined bull's-eyes of concentric laminae; astrorhizae imperceptible. Laminae thick, dense, irregular bands with scattered vacuoles. Pillars short, thick (0.08–0.20 mm across), isolated vermiform strands or dots (mostly irregular), rarely linking or coalescing. Microstructure apparently compact. Astrorhizae absent.

Material.—Two specimens, one partially dolomitized, the second severely dolomitized (Bathurst Island), identified as *Trupetostroma* sp. and represented by hypotype GSC 108884 (Pl. 12, figs. 3,4). Two additional specimens, poorly preserved and identified as *Trupetostroma* sp.?, are questionably assigned to this species and represented by hypotype GSC 108885 (not illustrated).

Discussion.—The basic concept of *Trupetostroma* embraces species with thick, pronouncedly tripartite laminae, thick, spool-shaped, superposed pillars, generally vacuolate microstructure, and common cyst-like dissepiments (*cf.* Parks, 1936; Stock, 1982). Bathurst Island *Trupetostroma* sp. herein departs somewhat from the norm by demonstrating poor pillar superposition and comparatively wide laminar spacing. Its mamelon development is comparatively strong, and the total absence of definable astrorhizal canals is unusual. Both dissepiments and skeletal vacuoles are comparatively few, but their scarcity may be due to diagenetic loss.

Trupetostroma dominantly occurs in rocks of Givetian to Frasnian age (*e.g.,* Lecompte, 1952; Galloway and St. Jean, 1957; Zukalová, 1971; Stearn, 1975b). Only a few species are known from Eifelian strata (*e.g., T. spatiosum, T.* cf. *schelomense* , *T. ramulosum* of Yavorsky, 1963; Kuznetsk Basin, Mamontovo Horizon, mid-Eifelian). No definitively Lower Devonian species are previously known. Two species described by Lessovaya (1970) as *T. globosum* and *T. magnifica,* from the Bursykhirmanian Horizon (lowest Lochkovian) of Uzbekistan, are incorrectly assigned to *Trupetostroma*; they show a definite microreticulate microstructure, and more plausibly belong to either *Parallelostroma* or *Coenostroma*.

A species quite similar to *Trupetostroma* sp. herein is *Trupetostroma*(?) sp. of Fagerstrom (1982), from the lower Detroit River Group, southwestern Ontario. The Arctic and Ontario species have very similar laminar and pillar spacings, both lack obvious astrorhizae, and in both pillar-vacuoles and dissepiments are poorly developed. Dissimilarities include stronger pillar superposition in the Ontario species, and more prominent mamelons and thicker compound laminae in the Arctic form. For both the Arctic and Ontario species, the material presently known is too scarce and poor to draw firm conclusions, but from the available evidence a close relationship is plausible. The correlation of Prosh and Stearn (1993) suggests that the Detroit River *Trupetostroma*(?) sp. of Fagerstrom (1982) is Late Emsian (probably *serotinus* Zone).

Two additional, poorly preserved specimens from the Upper Emsian portion of the Blue Fiord Formation at Vendom Fiord, Ellesmere Island, are questionably included here as *Trupetostroma* sp.? The Vendom Fiord specimens display similar laminar dimensions and spacing to the younger Bathurst Island *Trupetostroma* sp., but have substantially thickened pillars and, consequently, very little open gallery space. In both the Bathurst Island and Vendom Fiord forms, the material is too poor and meager to determine if the they are conspecific variants or separate species. For biostratigraphic purposes (Text-fig. 3), the Vendom Fiord occurrence is treated as a questionable range extension of *Trupetostroma* sp. down into the upper Emsian (*inversus-serotinus* Zones).

Occurrence.—Northeastern Bathurst Island, unnamed limestone formation, lower 100 m; highest Emsian/basal Eifelian (undifferentiated *patulus* Zone). *Trupetostroma* sp.?: Vendom Fiord, Ellesmere Island, Blue Fiord Formation, upper member; upper Emsian (*inversus-serotinus* Zones).

Order **STROMATOPORIDA** Stearn, 1980

Family **STROMATOPORIDAE** Winchell, 1867

Genus **STROMATOPORA** Goldfuss, 1826

Type species.—*Stromatopora concentrica* Goldfuss, 1826.

Stromatopora polaris (Stearn, 1983)
Plate 14, figure 5

Ferestromatopora jacquesensis Galloway. Stearn and Mehrotra, 1970, p. 20, pl. 5, figs. 5, 6.

Ferestromatopora polaris Stearn, 1983, p. 551–552, figs. 5A–C, 5E; 1989, fig. 1D.

Stromatopora polaris Stearn, 1990, p. 507, fig. 3.8.

?*Stromatopora* aff. *polaris* Stearn. Webby, Stearn and Zhen, 1993, p. 158, 161, figs. 5F, 23A–F, 24A.

Material.—Thirty-six specimens, ranging from poor to well preserved. Hypotype GSC 108886. Other specimens listed in Appendix 3.

Discussion.—*Stromatopora polaris* has been previously recorded in the Arctic Islands from the lower Blue Fiord Formation (Stearn, 1983) and from Upper Lochkovian reefal blocks in the Stuart Bay Formation, Bathurst Island (Stearn, 1990). The species is described in full in Stearn (1983).

The new specimens of *S. polaris* recognized here, from the Blue Fiord and Disappointment Bay formations, extend the species' range through most of the Emsian Stage, up to the *serotinus* Zone. Specimens from the upper Eids Formation, Ellesmere Island, are lowest Emsian, possibly uppermost Pragian. The full species range in the Arctic is therefore upper Lochkovian to upper Emsian.

Specimens from the unnamed formation on Truro and Bathurst Islands (undifferentiated *patulus* Zone; highest Emsian/basal Eifelian), identified as *Stromatopora hensoni* n. sp., are similar to *S. polaris,* and probably represent a descendant species.

Occurrence.—Eids Formation, upper 100 m; Ellesmere Island, Sör Fiord (five specimens); lowest Emsian (*dehiscens* Zone), possibly uppermost Pragian. Blue Fiord Formation, lower member; Ellesmere Island, vicinity type section (10 specimens), Eids Fiord (nine specimens), Vendom Fiord (two specimens), Sör Fiord (one specimen); lower Emsian (*dehiscens* Zone). Disappointment Bay Formation, reefs low in formation, Truro Island (five specimens); mid-Emsian (*inversus* Zone). Blue Fiord Formation, upper member; Ellesmere Island, vicinity type section (four specimens); upper Emsian (*serotinus* Zone).

Stromatopora cf. **S. hupschii** (Bargatzky, 1881)
Plate 13, figures 1,2

cf. *Caunopora hupschii* Bargatzky, 1881, p. 290.

cf. *Stromatopora hupschii* (Bargatzky). Nicholson 1886, pl. 10, figs, 8, 9; 1891, p. 176; Lecompte, 1952, p. 268, pl. 52, figs. 2, 2a, 2b; Yavorsky, 1955, p. 106, pl. 56, figs. 3, 4.

Stromatopora cf. *S. hupschii* (Bargatzky). Galloway, 1960, p. 627–628, pl. 74, figs. 2a, 2b; Stearn, 1983, p. 552–553, figs. 5D, 5F.

Description.—Skeleton domal to hemispherical, up to 15 cm diameter. Surface undulate, but without defined mamelons or perceptible astrorhizae.

Vertical section: Thick, dominantly cassiculate structural elements; common thin latilaminae. Skeletal elements variable thickness, 0.15–0.30 mm, commonly 0.20 mm; specimen averages 20.6 (GSC 108887, n=20), 19.9 (GSC 108888, n=10), 20.9 (GSC 108889, n=10) mm; network dominantly cassiculate, a merging of short vertical or sub-vertical segments, rare oblique segments, and rare, slightly thicker horizontal segments; short, coalescent coenosteles may occur very locally; coenostroms absent. Galleries circular to irregularly vermiform. Dissepiments uncommon, may be locally clustered at specific levels, or about inconspicuous astrorhizae. Latilaminae conspicuous, 2–4 mm thick, defined by darkened elements or thin sediment interlayers. Microstructure coarsely cellular, cellules 0.02–0.04 mm diameter. Astrorhizae inconspicuous.

Tangential section: Skeletal elements form tightly-closed, amalgamate network; element thickness 0.15–0.25 mm, commonly 0.20 mm; microstructure cellular. Galleries labyrinthine, slightly thinner than elements; rarely circular to sub-circular. Astrorhizae rare, ill-defined clusters of short canal segments, 0.30–0.40 mm diameter.

Material.—Six specimens, moderately well preserved. Hypotypes GSC 108887 to 108889.

Discussion.—The systematic assignment of this species is unchanged from that of Stearn (1983), despite the additional six specimens from the Blue Fiord and Eids Formations. The species *Stromatopora hupschii* remains no more than a convenient receptacle for specimens such as these, with thick structural elements but few other distinguishing features.

Occurrence.—Eids Formation, upper 100 m; Ellesmere Island, Sör Fiord (one specimen); lowest Emsian (*dehiscens* Zone), possibly uppermost Fragian. Blue Fiord Formation, lower member, Ellesmere Island; Eids Fiord (four specimens), Vendom Fiord (one specimen); lower Emsian (*dehiscens* Zone).

Stromatopora hensoni, new species

Plate 13, figures 3–5

Diagnosis.—Conspicuously latilaminate; alternating phases of dominantly cassiculate structure and phases with abundant microlaminae; abundant, vertically persistent astrorhizae.

Description.—Skeleton domical, up to 15 cm diameter; surface smooth.

Vertical section: Skeletal elements cassiculate; thickness variable 0.10–0.25 mm, commonly 0.15 mm, holotype GSC 108890 average 0.16 range 0.10–0.25 (n=20); microstructure finely cellular. Galleries circular to vermiform, 0.10–0.25 mm diameter. Alternating phases of cassiculate versus microlaminar structure, subequally thick 3–5 mm, but commonly cassiculate phases thickest/dominant; latilaminae prominent, thick 0.5–1.0 cm, composed of paired cassiculate plus microlaminar phases. Microlaminae thin 0.01 mm, incomplete; variably densely spaced, to as much as 10 to 15 per mm; rare to absent in cassiculate phases; generally poorly preserved. Dissepiments rare to absent. Astrorhizae large, vertically persistent; axial canal 0.40–0.60 mm diameter; lateral canals turning gradually to horizontal, 0.20–0.30 mm diameter. Parasitic borings common.

Tangential section: Meandriform bands of alternating 1) thicker, darker, labyrinthine elements (cassiculate phases), and 2) thinner, lighter-toned, diffuse structure (microlaminar phases). Skeletal elements labyrinthine to vermiform, 0.10–0.20 mm thick; microstructure finely cellular; galleries vermiform to subcircular, occupy less than half total area. Astrorhizae moderately large, well-formed; comprise central disordered bundle of axial canals 0.20 mm diameter, extensive radial network of thicker lateral canals 0.30 mm diameter; center-to-center spacing roughly 1.0 cm.

Material.—Three specimens, moderately well to well preserved. Holotype GSC 108890; paratypes GSC 108891 and GSC 108892.

Discussion.—In terms of its structural elements, this new species is similar to *Stromatopora polaris* (Stearn, 1983). The size and disposition of cassiculate structural elements in both species is very similar, and in *S. polaris* periodic microlaminae impart banding to the skeleton in vertical section. *Stromatopora hensoni* n. sp. is distinguished from *S. polaris* by the gross arrangement of its skeletal elements, into alternating phases of cassiculate structure (like *S. polaris*) and subordinate phases with abundant microlaminae. Its well developed and persistent astrorhizae are also unlike *S. polaris,* in which astrorhizae are poorly developed. This comparison suggests that *S. hensoni* n. sp. is an immediate descendant of *S. polaris.* This conclusion is supported by the stratigraphic distribution of these species: *S. polaris* is last known from the *serotinus* Zone (Blue Fiord Formation), and *S. hensoni* n. sp. appears in the succeeding undifferentiated *patulus* Zone.

Etymology.—To honor Matthew Henson, Arctic explorer, companion of Peary.

Occurrence.—Unnamed formation; southeastern Bathurst Island (Dyke Ackland Bay) (two specimens), Truro Island (one specimen); highest Emsian/basal Eifelian (undifferentiated *patulus* Zone).

Genus **FERESTROMATOPORA** Yavorsky, 1955

Type species.—*Ferestromatopora krupennikovi* Yavorsky, 1955.

Ferestromatopora cf. **F. krupennikovi** Yavorsky, 1955
Plate 14, figures 1,2

cf. *Ferestromatopora krupennikovi* Yavorsky, 1955, p. 109–110, pl. LVIII, figs. 1–5; Yang and Dong, 1979, p. 58, pl. 28, figs. 1, 2.
non *Ferestromatopora krupennikovi* Yavorsky. Fischbuch, 1969, p. 176–177, pl. IX, figs. 1–5.
?*Ferestromatopora krupennikovi* Yavorsky. Khromych, 1974, p. 52, pl. XIII, figs. 2a, 2b.

Description.—Skeleton domal, up to 8 cm diameter. Growth surfaces irregular, but without noticeable mamelons.

Vertical section: A highly irregular network of vertical-to-inclined elements and dissepiments, bounded by paralaminae. Paralaminae mostly continuous, undulate, thin 0.03–0.04 mm; spaced irregularly 0.3–1.4 mm apart, commonly 0.6–0.8 mm apart. Interlaminar network chaotic, consisting of short, vertical or inclined elements, 0.06–0.08 mm thick, merging with or bridged by abundant, convex dissepiments, 0.01–0.02 mm thick; where vertical elements abundant, spaced roughly 10 per 2 mm. Microstructure indeterminate. Galleries commonly squarish, arch-roofed, or irregular or sub-round; well-formed galleries 0.25–0.40 mm lateral diameter; galleries generally randomly offset, but immediately adjacent to paralaminae may align laterally. Basal layers thin, composed of stringy, sinuous, discontinuous vertical elements, and discontinuous paralaminae. Astrorhizae obscure; vertical systems imperceptible; lateral canals roughly 0.30 mm wide; dissepiments large and abundant within astrorhizae.

Tangential section: A tightly linked, cassiculate network; elements 0.03–0.06 mm thick, only rarely as isolated dots 0.03 mm diameter. Microstructure vaguely cellular. Paralaminae form thin, meandering bands, weak concentric arrangement. Astrorhizal canals numerous, appear as short, straight or simply branched segments, 0.20–0.35 mm wide; canals clustered, but otherwise without definable pattern.

Material.—One specimen, preservation mediocre. Hypotype GSC 108893.

Discussion.—This Blue Fiord specimen resembles *Ferestromatopora krupennikovi* Yavorsky, 1955 in a number of ways. Its cassiculate structural elements are similar in size and arrangement, and the wide range of spacing of paralaminae is identical. In the original description of the species, Yavorsky (1955) emphasized the cellular shape of the galleries, and characterized their arrangement relative to each other as "chess-like order", in other words alternately offset. In contrast, the galleries of the Blue Fiord specimen are more randomly arrayed, and a bit larger than in *F. krupennikovi.* The astrorhizal systems of the Blue Fiord specimen differ considerably from the type description, having somewhat wider canals, little discernable pattern, and no evident vertical component.

Of the few valid species of *Ferestromatopora* known (Stearn, 1993), all are Middle Devonian. *F. krupennikovi,* the type species of the genus, comes from the Givetian of the Kuznetsk Basin, Russia (Yavorsky, 1955). Therefore the Blue Fiord occurrence considerably extends the range of the genus to the lower Emsian.

Occurrence.—Ellesmere Island, Eids Fiord; Blue Fiord Formation, lower member; lowest Emsian (*dehiscens* Zone).

Genus **GLYPTOSTROMOIDES** Stearn, 1983

Type species.—*Glyptostroma simplex* Yang and Dong, 1979.

Glyptostromoides simplex (Yang and Dong, 1979)
Plate 14, figures 3, 4

Glyptostroma simplex Yang and Dong, 1979, p. 66, pl. 36, figs. 7, 8.
Glyptostromoides simplex (Yang and Dong). Stearn, 1983, p. 553, 555, figs. 6A–6C.

Discussion.—The Blue Fiord Formation occurrence of this species has been described by Stearn (1983).

Blue Fiord *Glyptostromoides simplex* displays a wide range of morphologies, as noted by Stearn (1983). Morphological variables include areas of cassiculate versus coenostromal structure, considerable variation in spacing of thick coenosteles, and abundance of dissepiments.

The eleven specimens of *G. simplex* referred to by Stearn (1983) came from strata low in the Blue Fiord Formation, in the vicinity of the type section. These strata are now regarded as lowest Emsian (*dehiscens* Zone) (Uyeno, 1990). Addition of the specimens considered here extends the range of Arctic *G. simplex* up to the *serotinus* Zone (upper Emsian).

Material.—Twelve specimens, moderately well to poorly preserved. Hypotypes GSC 108894, 108895. Other specimens listed in Appendix 3.

Occurrence.—Eids Formation, near formation top; Ellesmere Island, Eids Fiord (two specimens); lower Emsian (*dehiscens* Zone). Blue Fiord Formation, lower member, Ellesmere Island; vicinity type section (seven specimens), Eids Fiord (one specimen); lower Emsian (*dehiscens* Zone). Blue Fiord Formation, high in upper member; Ellesmere Island, vicinity type section; upper Emsian (*serotinus* Zone) (one specimen). Blue Fiord Formation, upper member, Vendom Fiord (Ellesmere Island), upper Emsian (*inversus* + *serotinus* Zones) (one specimen).

Family **SYRINGOSTROMELLIDAE** Stearn, 1980

Genus **SYRINGOSTROMELLA** Nestor, 1966

Type species.— Stromatopora borealis Nicholson, 1891.

Syringostromella zintchenkovi (Khalfina, 1961)
Plate 15, figures 1–3

Stromatopora aff. *hupschii* (Bargatzky). Ripper, 1937a, p. 186, pl. 8, figs. 7–8.

Stromatopora zintchenkovi Khalfina, 1960, p. 327–328, pl. D-3, figs. 1a, 1b.

Syringostromella zintchenkovi (Khalfina). Webby, Stearn and Zhen, 1993, p. 163, figs. 23E–F, 24A–C.

Description.—Skeleton laminar, thick; up to 15 cm lateral diameter. Surface not preserved.

Vertical section: Thick, persistent coenosteles, abundant dissepiments. Coenosteles vertically persistent, parallel to one another, straight or gently sinuous; may branch and coalesce vertically, but not commonly; thick, 0.20–0.40 mm, GSC 108896 range 0.21–0.35 mm average 0.27 mm (n=20), GSC 108897 range 0.20–0.40 mm average 0.27 mm (n=20); spacing 3 to 6 per 2 mm, commonly 4 to 5 per 2 mm, GSC 108896 range 3 to 4 average 3.8 per 2 mm (n=10), GSC 108897 range 4 to 6 average 4.7 per 2 mm (n=10). Short coenostromal segments locally present, up to 0.5 cm long, 0.25–0.30 mm thick. Dissepiments very abundant, thin, 0.02 mm; horizontal to gently convex, commonly spanning vertical galleries between coenosteles, but locally up to 0.5 mm long; commonly aligned laterally; vertical spacing 5 to 8 per mm. Microstructure finely cellular. Astrorhizae inconspicuous.

Tangential section: Coenosteles form tightly linked, labyrinthine network; galleries sausage-shaped rarely subcircular. Coenosteles 0.20–0.40 mm thick; microstructure finely cellular. Astrorhizae inconspicuous, evident only as short canal segments, 0.30 mm wide.

Material.—Two specimens. Hypotypes GSC 108896, 108897. Moderately well preserved.

Discussion.—*Syringostromella zintchenkovi* (Khalfina, 1961) is previously known from the Salair of south-central Russia, Krekovski horizon (upper Lochkovian). The Blue Fiord Formation specimens conform very closely to the original description of Khalfina (1961): coenosteles 0.17–0.32 mm, commonly 0.21–0.29 mm thick, rarely thicker, spacing 2 to 3 per mm. Khalfina (1961) characterized the "zooidal tubes" (intercoenostele galleries) as somewhat narrower than the coenosteles themselves, the same condition as in the Blue Fiord specimens. Although Khalfina (1961) gave dimensions for the astrorhizae, they are described as small and poorly-defined; in the Blue Fiord specimens astrorhizae are scarcely apparent.

Syringostromella zintchenkovi may be confused with certain specimens of *Salairella prima* Khromych, 1971, which both occur in the lower Emsian portion of the Blue Fiord Formation. In vertical section, the coenosteles of *Salairella prima* are generally thinner and more vertically coalescent, but a few specimens of *S. prima* have coenosteles approaching the condition of *Syringostromella zintchenkovi,* and if dissepiments are unusually abundant, the species may be difficult to distinguish. Ultimately, *Syringostromella* and *Salairella* must be discriminated in tangential section; *Syringostromella* forms a tight labyrinthine network, and in *Salairella* round coenotubes predominate.

Blue Fiord *Syringostromella zintchenkovi* is similar to *Syringostromella labyrinthea* Stearn, 1990 from Lochkovian reefal blocks on Bathurst Island (Stearn, 1990). In *S. labyrinthea,* however, the coenosteles are thinner and more closely spaced. Stearn (1990) synonomized *S. labyrinthea* and *S.* cf. *zintchenkovi tenuis* Khalfina, 1961 of Khromych (1976), a form found in the Emsian of eastern Siberia. *S. zintchenkovi tenuis* itself was established by Khalfina (1961), for specimens younger than *S. zintchenkovi* s.s, from the Malobachatski horizon (Pragian, overlies the Krekovski horizon), and with thinner and more closely spaced coenosteles than *S. zintchenkovi.* It therefore appears that in the arctic Lower Devonian, older *Syringostromella* has the thinner elements, and in Siberia the opposite occurs, with thinner elements in younger forms of *Syringostromella.* As such, this *Syringostromella zintchenkovi-labyrinthea* assemblage of species is of dubious biostratigraphic value.

Syringostromella zintchenkovi has also recently been recognized from the lower Pragian Lilydale Limestone of Victoria, Australia (Webby *et al.*, 1993).

Occurrence.—Blue Fiord Formation, lower member; Ellesmere Island, formation type area (one specimen), Sör Fiord (one specimen); lower Emsian (*dehiscens* Zone).

Genus **SALAIRELLA** Khalfina, 1961

Type species.—*Salairella multicea* Khalfina, 1961.

Salairella prima Khromych, 1971
Plate 15, figures 4, 5; Plate 16, figures 1–5

Salairella prima Khromych, 1971, p. 132, pl. 36, figs. 1a, 1b; Stearn, 1983, p. 555–556, figs. 6D–6G; Webby and Zhen, 1993, p. 342, 344, figs. 9C–E, 12A, B.

Material.—Twenty-nine specimens. Hypotypes GSC 108898 to 108901. Other specimens listed in Appendix 3. Poor to exceptionally well preserved.

Discussion.—The Blue Fiord Formation occurrence of this species is described by Stearn (1983).

The new specimens of *Salairella prima* recognized herein allow for some broadening of the concept of this species. Of the 29 specimens assigned to *S. prima,* 22 of them conform to the description of Stearn (1983). Four of the new specimens exhibit a greater abundance of dissepiments, but in all other features conform to the earlier description (Stearn, 1983). In vertical section (Pl. 16, fig. 1), the abundant dissepiments are arranged like tabulae, ascending the vertical galleries between the coenosteles. The dissepiments are small and very thin, so that in many specimens their scarcity may be due in some degree to diagenetic removal.

As noted by Stearn (1983), the majority of specimens of *S. prima* demonstrates only obscure and inconspicuous astrorhizae. Two of the new specimens, however, exhibit well formed, although widely scattered astrorhizae (Pl. 16, fig. 2). In these rare specimens the astrorhizae form radiating lateral branches 0.20–0.25 mm across.

Specimens of *S. prima* in the original collection of Stearn (1983) came from low in the Blue Fiord Formation, in lower Emsian strata (*dehiscens* Zone). The new specimens extend the species' range in the Arctic up to the upper Emsian (*serotinus* Zone). The type of *S. prima* is from the Neludimskaya suite in the Omulevski Range of Severo-Vostok, eastern Siberia (Khromych, 1971). Although Khromych (1971) indicated the age of these rocks as Middle Devonian (reiterated in Stearn, 1983), in a later publication (Khromych, 1976) the Neludimskaya suite is shown to be Early Devonian (probably Pragian) in age. *S. prima* has recently been described (Webby and Zhen, 1993) from the Jesse Limestone, New South Wales, Australia, where it is Emsian, probably early Emsian age.

A few of the new specimens of *S. prima* preserve microstructure in very fine detail (Pl. 16, figs. 3–5). For the most part, the microstructure of *S. prima* is finely cellular (*e.g.* Pl. 16, fig. 3). In some specimens (most notably GSC 108898, Pl. 16, fig. 5), however, the "cellules" are strongly aligned at certain levels, such that the microstructure becomes orthoreticulate. Stearn (1983) made a similar observation, noting the microstructure of *S. prima* as cellular with local traces of microreticulation. Webby and Zhen (1993) have also studied the microstructure of *S. prima*, suggesting that it is probably microreticulate rather than cellular. The distinction between skeletal tissue in which the cellules are aligned vertically and that in which micropillars and microcolliculi define the microarchitecture is a subtle one. In the recent phylogeny of the Stromatoporida proposed by Stearn (1993) microreticulate genera are grouped in the Order Syringostromatida and cellular genera are placed in the Stromatoporida. *Salairella* is placed here in the Stromatoporida because the microstructure of most of its species is dominantly cellular. If *Salairella prima* is interpreted as typically microreticulate, then its ancestry would be interpreted by Stearn (1993) as within the Syringostromatida and distant from that of the Stromatoporida. The species appears to show both microreticulate and cellular microstructure. If microstructure is taken as the sole criterion of membership in the Syringostromatida and the species is dominantly microreticulate, then *S. prima* should be transferred to the genus *Parallelopora* Bargatzky within this order.

The ambiguity of the microstructure of *S. prima* is made no clearer when specimens are viewed in tangential section (Pl. 16, figs. 3,4). Stearn (1993) has suggested that microreticulate and cellular microstructure may be discriminated when viewed in tangential section, by noting the character of microelements at the edge of skeletal (macro)galleries. Coenosteles with protruding microcolliculi at gallery edges should produce a ragged boundary; in contrast, coenosteles of cellular microstructure should have smooth gallery edges. Unfortunately such ragged edges may be easily corroded in diagenesis. Specimens of *Salairella prima* exhibit both these features in tangential section (Pl. 16, figs. 3,4), implying the genuine coexistence of both microstructures.

Detailed assessment of the classification of the Stromatoporida and the position of *Salairella prima* in it is beyond the scope of this study. If *S. prima* can be shown to be basically more microreticulate than cellular, then it should be transferred to a genus within the Syringostromatida. If, on the other hand, the suggestion of microreticulation is the result of occasional superposition of cellules (rather than a basic post-and-beam microarchitecture) then it can be retained within the Stromatoporida.

Occurrence.—Eids Formation, upper 100 m; Ellesmere Island, Eids Fiord (one specimen), Sör Fiord (five specimens); lower Emsian (*dehiscens* Zone), possibly uppermost Pragian. Blue Fiord Formation, Ellesmere Island; lower member, lower 150 m; vicinity type section (10 specimens); Eids Fiord (five specimens); Sör Fiord (two specimens); Vendom Fiord (three specimens); lower Emsian (*dehiscens* Zone). Disappointment Bay Formation, reefs near base of formation; Truro Island (one specimen), Lowther Island (one specimen); mid-Emsian (*inversus* Zone). Blue Fiord Formation, upper member, near top; Ellesmere Island, vicinity type section; upper Emsian (*serotinus* Zone) (one specimen).

Order **SYRINGOSTROMATIDA**
Bogoyavlenskaya, 1969

Family **SYRINGOSTROMATIDAE** Lecompte, 1951

Genus **ATOPOSTROMA** Yang and Dong, 1979

Type species.—*Atopostroma tuntouense* Yang and Dong, 1979.

Atopostroma distans (Ripper, 1937b)
Plate 18, figure 5

Actinostroma stellulatum var. *distans* Ripper, 1937b, p. 12, pl. 2, figs. 1,2.
Trupetostroma cf. *T. ideale* Birkhead. Stearn and Mehrotra, 1970, p. 16–17, pl. 5, figs. 1, 2.
Atopostroma tuntouense Yang and Dong. Stearn, 1983, p. 548–549, figs. 4E–H.
Atopostroma distans (Ripper). Webby and Zhen, 1993, p. 346–348; figs. 11A–D, 12E; Webby, Stearn and Zhen, 1993, p. 171, 173, figs. 27F, 28A–D.

Material.—Four specimens. Hypotype GSC 108902. Preservation mediocre to moderately well preserved.

Discussion.—The Blue Fiord Formation occurrence of this species has been previously described by Stearn (1983) as *Atopostroma tuntouense* Yang and Dong, 1979. The four specimens of *Atopostroma distans* recorded here, including one from the Bird Fiord Formation, display the following measurements: laminar spacing 7 to 11 per 2 mm (averages n=10 each specimen: 8.4, 8.4, 9.5, 9.9); pillar spacing 8 to 10 per 2 mm (averages n=10 each specimen: 9.2, 8.6, 8.7, 9.0); laminar thickness 0.02–0.04 mm; pillar thickness 0.08–0.10 mm.

Blue Fiord specimens earlier assigned to *Atopostroma tuntouense* by Stearn (1983) have been referred to *Atopostroma distans* (Ripper) (Webby and Zhen, 1993). In Australia, *A. distans* is known from the Emsian Jesse Limestone, New South Wales (Webby and Zhen, 1993), and from the Buchan's Cave Limestone, Victoria (basal Emsian) (Webby *et al.*, 1993). As noted in Webby and Zhen (1993) and Webby *et al.* (1993), specimens referred to *Atopostroma tuntouense* from the upper Lochkovian Stuart Bay Formation of Bathurst Island (Stearn, 1990) are not conspecific with Blue Fiord specimens.

Occurrence.—Blue Fiord Formation, lower member, Ellesmere Island; Eids Fiord (two specimens), vicinity formation type section (one specimen); lower Emsian (*dehiscens* Zone). Bird Fiord Formation, near formation base; Ellesmere Island, Bird Fiord (near type locality) (one specimen); uppermost Emsian/basal Eifelian (undifferentiated *patulus* Zone).

Genus **HABROSTROMA** Fagerstrom, 1982

Type species.—*Stromatopora proxilaminata* Fagerstrom, 1961.

Habrostroma proxilaminatum (Fagerstrom, 1961)
Plate 17, figures 1–5

Stromatopora proxilaminata Fagerstrom, 1961, p. 8, pl. 1, figs. 4–6.
Habrostroma proxilaminata (Fagerstrom). Fagerstrom, 1982, p. 13–15, pl. 1, figs. 7, 8.

Description.—Skeleton hemispherical to subspherical, up to 10 cm diameter. Growth surfaces with barely perceptible mamelons of very low relief, astrorhizae present.

Vertical section: Structure a network of microlaminae and much thicker, diffuse pillars. Microlaminae continuous, very gently undulate, may coalesce laterally; 0.01–0.03 mm thick; readily obscured by diagenesis, may locally appear as a chain of fine dots or beads; spacing variable, 10 to 20 per 2 mm, average 14.6 (n=11). Latilamination irregular, marked by dark perithecal layers following growth interruption, thickness very variable, 2 mm to 2 cm. Pillars stout, 0.10–0.15 mm thick; mostly column-like, or may expand gently upward to coalesce at overlying microlamina, forming coenostroms; mostly vertical, some gently inclined; commonly confined to interlaminar space, irregularly offset, less than half total pillars superposed over two coenostroms, rarely superposed over 3 to 4; spaced 7 to 11 per 2 mm, average 8.4 (n=17). Pillar microstructure orthoreticular to clinoreticular, but preservation generally poor. Galleries commonly circular or oval (long-axis horizontal), mostly 0.2–0.3 mm across, rarely horizontally elongate to 0.5 mm or more. Astrorhizal systems well developed, large and vertically persistent; no axial canal, lateral canals 0.15–0.20 mm wide; inclined tabulae common along lateral branches, otherwise absent in skeleton.

Tangential section: A tangled, irregular network exhibiting very little open gallery space. Laminae (coenostroms) thick, diffuse, concentric bands. Microlaminae imperceptible. Pillars form irregular, interconnected chains, 0.10–0.15 mm thick; only very rarely as isolated irregular dots between laminae. Microstructure cellular (=irregular microreticular). Astrorhizae conspicuous, common; canals 0.20–0.25 mm diameter; comprised of about 8 to 10 radiating lateral canals, no axial canal; center-to-center distance fairly consistent, about 6 mm; present at mamelon summits, but not confined to them.

Material.—Seventeen specimens, moderately well to poorly preserved. Hypotypes GSC 108903 to 108905. Other specimens listed in Appendix 3.

Discussion.—*Habrostroma proxilaminatum* is previously known from the Devonian of southwestern Ontario (Fagerstrom, 1961, 1982), and the Arctic specimens differ very little from Fagerstrom's descriptions. Fagerstrom (1982) distinguished *H. proxilaminatum* from two similar species (*H. densilaminatum* and *H. formosense*) primarily on the basis of microlaminar spacing, recognizing a continuum of variation between the three species, with *H. proxilaminatum* intermediate in position, having microlaminar spacing on the order of 15 to 22 per 2 mm. The spacing of the Arctic specimens falls slightly lower (10 to 20 per 2 mm, average 14.6), thus approaching the field of *H. densilaminatum.* The poorer preservation of the Arctic specimens suggests some diagenetic loss of microlaminae, biasing the measurements towards artificially low values. Fagerstrom's (1961) original description of the species cites a wider pillar spacing (2 to 3 per 1 mm), but his photographs (1961, 1982) demonstrate pillar spacing comparable to that of the arctic specimens. In all other significant features the arctic and southern Ontario specimens are identical: pillar thickness and arrangement; gallery shape, size, and disposition; astrorhizal size, abundance, spacing, lack of axial canal, and exclusivity of tabulae.

In the Devonian of Ontario, *H. proxilaminatum* is long-ranging, occurring in the Detroit River Group through the upper Dundee Formation, and possibly in the underlying Bois Blanc Formation (Fagerstrom, 1982). In the Arctic, *H. proxilaminatum* is known to occur at two localities, in the lower Disappointment Bay Formation on Truro Island, in strata of mid-Emsian age, and in the lower unnamed formation on Bathurst Island, in strata spanning the Emsian–Eifelian boundary. Its observed range in the Arctic is therefore from the *inversus* Zone through the undifferentiated *patulus* Zone (Text-figure 3). The Arctic occurrence of *H. proxilaminatum* further strengthens the Blue Fiord-to-Detroit River correlation of Prosh and Stearn (1993), in which common stromatoporellid species are interpreted to give an *inversus*-age for the Bois Blanc Formation, and a *serotinus*-age for much of the Detroit River Group. By this correlation, the *inversus–patulus* range of Arctic *H. proxilaminatum* corresponds to the Bois Blanc through Detroit River interval of its range in Ontario. Also, the addition of *H. proxilaminatum* to the correlation indicates that a major migration of Arctic stromatoporoids to the midcontinent took place during late Emsian time.

Oddly, *H. proxilaminatum* is absent from our large Blue Fiord Formation collections, yet at Truro Island one-half of the specimens collected are *H. proxilaminatum.* That this is no sampling artifact is show by the large discrepancy in abundance of samples. It is interpreted to indicate a clear environmental preference. The depositional setting of Truro Island is quite unlike the large, shelf-margin reefs of the type Blue Fiord on Ellesmere Island; rather, very small reef knolls in a restricted, platformal setting are indicated for the Disappointment Bay Formation on Truro Island. Fagerstrom (1961) noted that *H. proxilaminatum* is the most abundant stromatoporoid species in the Formosa reefs (lower Detroit River Group) of southern Ontario.

Occurrence.—Truro Island; Disappointment Bay Formation, small reef knolls near base of formation; mid-Emsian (*inversus* Zone) (15 specimens). Bathurst Island, Dyke Ackland Bay; unnamed limestone formation, lower 100 m; highest Emsian/basal Eifelian (undifferentiated *patulus* Zone) (two specimens).

Genus **PARALLELOPORA** Bargatzky, 1881

Type species.—Parallelopora ostiolata Bargatzky, 1881.

Parallelopora campbelli
Galloway and St. Jean, 1957
Plate 18, figures 1–4

Parallelopora campbelli Galloway and St. Jean, 1957, p. 208–210, pl. 19, figs. 3a, b.

Description.—Skeleton tabular, up to 10 cm diameter. Growth surface undulating, but without defined mamelons.

Vertical section: An irregular network of branching and anastomosing coenosteles, with only short, discontinuous coenostroms. Coenosteles 0.05–0.15 mm thick, most commonly 0.10 mm thick; mostly vertically aligned, continuous over 1 to 4 coenostromal bands, or branching and coalescing; locally in small areas of irregular network vertical fabric is suppressed; spacing regular, 7 to 10 per 2 mm; specimen GSC 110314, 7 to 10 per 2 mm average 8.3 (n=20); specimen GSC 110315, 7 to 9 per 2 mm average 7.7 (n=10); specimen GSC 110316, 7 to 10 per 2 mm average 8.4 (n=10). Coenostele microstructure orthoreticulate, microgalleries 0.04 mm diameter. Horizontal fabric suppressed; locally coenosteles may merge laterally to produce short coenostromal segments about 5 mm long, 0.10–0.20 mm thick; where partial coenostroms occur in sequence, spacing roughly 6 to 8 per 2 mm. Dissepiments present, not abundant; common within and adjacent to astrorhizae; elsewhere dissepiments very flat, joining laterally over short lengths locally suggesting microlaminae. Latilaminae absent, although 3 to 5 mm thick bands of strongly aligned coenosteles alternating with cassiculate network suggest growth periodicity. Galleries subequally vertically elongate, roughly 0.15 mm wide by 0.30–0.40 mm long, or round, 0.15–0.25 mm diameter. Astrorhizae irregular, vertically persistent; canals wide, 0.25–0.40 mm; unassociated with any structural deflection within skeleton.

Tangential section: A dense network with little open gallery space. Horizontal fabric imperceptible, little suggestion of concentric banding apparent. Coenosteles chainlike, joined, not separate; thickness highly variable, 0.05–0.25 mm, commonly 0.10 mm, locally fused into thick clumps; occuping over half total area. Microgalleries 0.04 mm diameter. Galleries either short vermiform areas, 0.10 mm wide, or round coenotubes 0.10 mm diameter. Astrorhizae common; inconsistently formed, may consist of a loose central bundle of a few axial canals, surrounded by 3 to 6 irregular radiating lateral canals; lateral canal width variable, 0.20–0.30 mm; center-to-center spacing 5–8 mm.

Material.—Five specimens, moderately well preserved. Hypotypes GSC 110314 to 110316.

Discussion.—*Parallelopora campbelli* is previously known from the Devonian of Indiana and Ohio (Galloway and St. Jean, 1957). It is, unfortunately, known from only a few specimens, and Galloway and St. Jean's description is based on the unique holotype. Despite this, the Arctic specimens are identical to Galloway and St. Jean's description in every significant regard. Pillar thickness and spacing are identical in both the Arctic specimens and the holotype, and they have comparable microstructure. The discontinuous coenostroms of the Arctic specimens compare to what Galloway and St. Jean (1957, p. 209) described as "variable and discontinuous" laminae, and thicknesses and spacings are the same. Similarly, Galloway and St. Jean (1957, p. 209) noted "discontinuous microlaminae and curved plates", described as dissepiments herein. In tangential section, the holotype and Arctic specimens show the same subequal distribution of vermicular and round galleries (= coenotubes). Of particular note are the odd astrorhizae and complete lack of mamelons.

In their systematic description of the species, Galloway and St. Jean (1957, p. 210) mentioned the occurrence of only the holotype, from the Jeffersonville Limestone near Kent, Indiana. Elsewhere (p. 80) they noted its rare occurrence in the "Columbus limestone" at Kelleys Island, Ohio. This latter mention is important, because it permits a more precise appraisal of the age of *P. campbelli.* In a detailed study of the stromatoporoids of Kelleys Island, Bjerstedt and Feldmann (1985) indicated that Galloway and St. Jean's "Columbus" stromatoporoids in fact come from the upper Lucas Formation (Detroit River Group). *P. campbelli* is not recorded in Fagerstrom's (1982) large Detroit River Group collections.

P. campbelli therefore constitutes another element in a major exchange of stromatoporoid species between the Arctic and the midcontinent during the late Emsian. The limited occurrence of *P. campbelli* in both the Arctic and midwest precludes precise correlation, but the ages of these known occurrences are closely comparable. Following from the stromatoporellid-based correlation of Prosh and Stearn (1993), the upper Lucas Formation is either of *serotinus* or more probably *patulus* Zone assignment. The Arctic specimens come from one locality dated as undifferentiated *patulus* Zone (*patulus* + *partitus* Zones; *cf.* Text-fig. 3), but on the basis of regional stratigraphy (Prosh and Stearn, 1993), believed most probably to be of *patulus*-age. The foregoing suggests that the Arctic and midwest specimens are of identical age, but too much uncertainty remains concerning their respective stratigraphic ranges. It is also quite possible that the range of Arctic *P. campbelli* extends down into the *serotinus* Zone; the Blue Fiord Formation at this level is dolomitic and poorly fossiliferous, and we have few stromatoporoids collected from this interval.

Occurrence.—Bathurst Island, Dyke Ackland Bay; unnamed formation, lower 100 m; highest Emsian/basal Eifelian (undifferentiated *patulus* Zone).

Appendix 1.—Collection localities.

Number on text-fig. 1	*location of sections**	*latitude N*	*longitude W*
1	AD	77°20′2″	86°49′31″
2	AA	77°20′2″	86°46′26″
3	AB	77°20′2″	86°41′11″
4	AC	77°19′56″	86°36′26″
5	BC	77°14′21″	86°19′3″
6	CA	77°17′15″	85°45′28″
7	CB	77°15′0″	85°51′12″
8	CC	77°16′27″	85°47′9″
9	CD	77°17′18″	85°47′37″
10	CF	77°14′28″	85°51′26″
11	CH	77°16′7″	85°51′26″
12	IA	77°16′59″	86°1′26″
13	IB	77°17′9″	85°55′57″
14	IC	77°16′59″	86°7′8″
15	ID	77°17′5″	85°57′9″
16	Castle bioherm	77°16′0″	85°45′0″
17	EA	77°17′28″	85°7′8″
18	EC	77°17′34″	85°9′31″
19	K	77°17′12″	85°8′34″
20	Bird Fiord Type	77°12′30″	86°35′20″
21	(no section)	77°16′0″	85°54′0″
22	ED	77°29′41″	83°54′17″
23	U-9	77°20′0″	86°36′26″
24	FA	77°36′19″	88°29′3″
25	KB	76°37′36″	87°38′48″
26	GA	77°44′28″	83°29′3″
27	GB	77°42′42″	83°30′0″
28	HA	76°35′2″	83°42′23″
29	HB	77°31′59″	83°48′6″
30	Loc. 43	77°27′35″	83°45′43″
31	Vendom 1	77°39′45″	83°31′0″
32	Vendom 4	77°27′35″	83°45′93″
33	Lowther Island	74°33′30″	97°29′30″
34	Truro Island	75°23′45″	97°13′10″
35	B22 (Bathurst I.)	76°29′14″	98°14′42″
36	B42A (Bathurst I.)	75°3′51″	99°8′37″

* Letters (*e.g.*, AD) designate measured sections in Smith (1984).

Appendix 2.—Catalogue of type numbers and locations of type specimens. Specimens in type collection of the Geological Survey of Canada, Ottawa.

GSC #	*species name*	*type*	*formation*	*interval*	*location*	*lat. north*	*long. west*
108175	*Stromatoporella perannulata*	hypo	Blue Fiord	154.1 m	1	77°20′2″	86°49′31″
108176	*Stictostroma gorriense*	hypo	Blue Fiord	0 m	8	77°16′27″	85°47′9″
108177	*Stictostroma gorriense*	hypo	Blue Fiord	0 m	8	77°16′27″	85°47′9″
108852	*Actinostroma* sp. A	hypo	unnamed	base	34	75°17′0″	97°11′30″
108853	*Plectostroma salairicum*	hypo	unnamed	lower 100 m	36	75°3′51″	99°8′37″
108854	*Plectostroma salairicum*	hypo	unnamed	lower 100 m	36	75°3′51″	99°8′37″
108855	*Aculatostroma* cf. *A. kaljanum*	hypo	Blue Fiord	75.9 m	27	77°42′42″	83°30′0″
108856	*Clathrodictyon ellesmerense*	hypo	Blue Fiord	70 m	6	77°17′15″	85°45′28″
108857	*Clathrodictyon ellesmerense*	hypo	Blue Fiord	86 m	15	77°17′5″	85°57′9″
108858	*Clathrodictyon ellesmerense*	hypo	Blue Fiord	103.4 m	26	77°44′28″	83°29′3″
108859	*Gerronostroma septentrionalis*	holo	Blue Fiord	base	3	77°20′2″	86°41′11″
108860	*Gerronostroma septentrionalis*	para	Blue Fiord	lower 100 m	4	77°19′56″	86°36′26″
108861	*Gerronostroma septentrionalis*	para	Blue Fiord	91.2 m	27	77°42′42″	83°30′0″
108862	*Gerronostroma septentrionalis*	para	Blue Fiord	5.9 m	13	77°17′9″	85°55′57″
108863	*Petridiostroma* sp.	hypo	Blue Fiord	163.4 m	24	76°36′19″	88°29′3″
108864	*Petridiostroma* sp.	hypo	Blue Fiord	base upper mem.	27	77°39′45″	83°31′0″
108865	*Atelodictyon* cf. *A. solidum*	hypo	Blue Fiord	ca. 200 m	25	76°37′36″	87°38′48″
108866	*Anostylostroma anfractum*	holo	unnamed	lower 100 m	35	76°29′14″	98°14′42″
108867	*Anostylostroma anfractum*	para	unnamed	lower 100 m	35	76°29′14″	98°14′42″
108868	*Anostylostroma anfractum*	para	unnamed	lower 100 m	35	76°29′14″	98°14′42″
108869	*Anostylostroma anfractum*	para	unnamed	lower 100 m	35	76°29′14″	98°14′42″
108870	*Pseudoactinodictyon conglutinatum*	holo	Blue Fiord	120 m	5	77°14′21″	86°19′3″
108871	*Pseudoactinodictyon conglutinatum*	para	Blue Fiord	120 m	5	77°14′21″	86°19′3″
108872	*Schistodictyon*? sp.	hypo	Blue Fiord	77.1 m	7	77°15′0″	85°51′12″
108873	*Stictostroma gorriense*	hypo	Blue Fiord	0 m	8	77°16′27″	85°47′9″
108874	*Stictostroma gorriense*	hypo	Blue Fiord	0 m	8	77°16′27″	85°47′9″
108875	*Stictostroma gorriense*	hypo	Blue Fiord	11.4 m	3	77°20′2″	86°41′11″
108876	*Stictostroma*? *nunavutense*	holo	Blue Fiord	11.4 m	3	77°20′2″	86°41′11″
108877	*Stictostroma*? *nunavutense*	para	Blue Fiord	lower 100 m	4	77°19′56″	86°36′26″
108878	*Stictostroma*? *nunavutense*	para	Blue Fiord	lower 100 m	4	77°19′56″	86°36′26″
108879	*Stromatoporella perannulata*	hypo	Blue Fiord	157.4 m	18	77°17′34″	85°9′31″
108880	*Stromatoporella perannulata*	hypo	Blue Fiord	157.4 m	18	77°17′34″	85°9′31″
108881	*Clathrocoilona vexata*	holo	Blue Fiord	11.4 m	3	77°20′2″	86°41′11″
108882	*Clathrocoilona vexata*	para	Blue Fiord	29.4 m	2	77°20′2″	86°46′26″
108883	*Clathrocoilona vexata*	para	Blue Fiord	11.4 m	3	77°20′2″	86°41′11″
108884	*Trupetostroma* sp.	hypo	unnamed	lower 100 m	35	76°29′14″	98°14′42″
108885	*Trupetostroma* sp.?	hypo	Blue Fiord	upper mem.	31	77°39′45″	83°31′0″
108886	*Stromatopora polaris*	hypo	Disappointment Bay	basal	34	75°23′45″	97°13′10″
108887	*Stromatopora* cf. *S. hupschii*	hypo	Blue Fiord	33.9 m	3	77°20′2″	86°41′11″
108888	*Stromatopora* cf. *S. hupschii*	hypo	Blue Fiord	29.4 m	2	77°20′2″	86°46′26″
108889	*Stromatopora* cf. *S. hupschii*	hypo	Blue Fiord	11.4 m	3	77°20′2″	86°41′11″
108890	*Stromatopora hensoni*	holo	unnamed	base	34	75°17′0″	97°11′30″
108891	*Stromatopora hensoni*	para	unnamed	lower 100 m	36	75°3′51″	99°8′37″
108892	*Stromatopora hensoni*	para	unnamed	lower 100 m	36	75°3′51″	99°8′37″
108893	*Ferestromatopora* cf. *F. krupennikovi*	hypo	Blue Fiord	140 m	2	77°20′2″	86°46′26″
108894	*Glyptostromoides simplex*	hypo	Blue Fiord	upper mem.	5	77°39′45″	83°31′0″
108895	*Glyptostromoides simplex*	hypo	Blue Fiord	1403 m	5	77°14′21″	86°19′3″
108896	*Syringostromella zintchenkovi*	hypo	Blue Fiord	117 m	18	77°17′34″	85°9′31″
108897	*Syringostromella zintchenkovi*	hypo	Blue Fiord	34.5 m	15	77°17′5″	85°57′9″
108898	*Salairella prima*	hypo	Blue Fiord	5.9 m	13	77°17′9″	85°55′57″
108899	*Salairella prima*	hypo	Blue Fiord	137.9 m	19	77°17′12″	85°8′34″
108900	*Salairella prima*	hypo	Blue Fiord	lower 100 m	30	77°27′35″	83°45′43″
108901	*Salairella prima*	hypo	Blue Fiord	29.4 m	2	77°20′2″	86°46′26″
108902	*Atopostroma distans*	hypo	Blue Fiord	102 m	2	77°20′2″	86°46′26″
108903	*Habrostroma proxilaminatum*	hypo	Disappointment Bay	basal	34	75°23′45″	97°13′10″
108904	*Habrostroma proxilaminatum*	hypo	Disappointment Bay	basal	34	75°23′45″	97°13′10″
108905	*Habrostroma proxilaminatum*	hypo	Disappointment Bay	basal	34	75°23′45″	97°13′10″
110314	*Parallelopora campbelli*	hypo	unnamed	lower 100 m	36	75°3′51″	99°8′37″
110315	*Parallelopora campbelli*	hypo	unnamed	lower 100 m	36	75°3′51″	99°8′37″
110316	*Parallelopora campbelli*	hypo	unnamed	lower 100 m	36	75°3′51″	99°8′37″

Appendix 3.—Collecting locations and stratigraphic position of specimens identified in this study (other than type specimens). Specimens in general collections of the Geological Survey of Canada, Ottawa.

Species	*specimen no.*	*formation*	*interval*	*location*
Aculatostroma cf. *A. kaljanum*	110-132	Blue Fiord	76–89 m	1
Clathrodictyon ellesmerense	110-115	Blue Fiord	11.4 m	3
Clathrodictyon ellesmerense	110-119	Blue Fiord	67.7 m	2
Clathrodictyon ellesmerense	110-142	Blue Fiord	29.4 m	2
Clathrodictyon ellesmerense	110-263	Blue Fiord	0 m	28
Clathrodictyon ellesmerense	110-267	Blue Fiord	0 m	28
Clathrodictyon ellesmerense	110-289	Blue Fiord	5.9 m	13
Clathrodictyon ellesmerense	110-176	Blue Fiord	35 m	6
Clathrodictyon ellesmerense	110-286	Blue Fiord	44.5 m	15
Clathrodictyon ellesmerense	110-135	Blue Fiord	8.9 m	2
Clathrodictyon ellesmerense	110-177	Blue Fiord	near base	2
Clathrodictyon ellesmerense	110-248	Blue Fiord	39.6 m	12
Clathrodictyon ellesmerense	110-212	Blue Fiord	near base	2
Clathrodictyon ellesmerense	110-288	Blue Fiord	12 m	14
Clathrodictyon ellesmerense	110-x	Blue Fiord	near base	1
Clathrodictyon ellesmerense	111-15	Blue Fiord	upper mem.	31
Clathrodictyon ellesmerense	129-10	Disappointment Bay	basal	34
Clathrodictyon ellesmerense	111-24	Bird Fiord	near base	20
Clathrodictyon ellesmerense	110-372	unnamed	lower 100 m	36
Gerronostroma septentrionalis	110-128	Blue Fiord	lower 100 m	9
Gerronostroma septentrionalis	110-172	Blue Fiord	near base	4
Gerronostroma septentrionalis	110-179	Blue Fiord	near base	4
Gerronostroma septentrionalis	110-189	Blue Fiord	near base	4
Gerronostroma septentrionalis	110-191	Blue Fiord	near base	4
Gerronostroma septentrionalis	110-238	Blue Fiord	124.3 m	18
Gerronostroma septentrionalis	110-241	Blue Fiord	64.4 m	13
Gerronostroma septentrionalis	110-272	Blue Fiord	44.5 m	15
Gerronostroma septentrionalis	110-327	Blue Fiord	21 m	9
Gerronostroma septentrionalis	110-204	Blue Fiord	17 m	6
Gerronostroma septentrionalis	110-309	Blue Fiord	13 m	9
Gerronostroma septentrionalis	110-361	Blue Fiord	13 m	9
Gerronostroma septentrionalis	110-363	Blue Fiord	77.1 m	10
Gerronostroma septentrionalis	110-364	Blue Fiord	77.1 m	10
Gerronostroma septentrionalis	110-221	Blue Fiord	124.3 m	18
Gerronostroma septentrionalis	110-247	Blue Fiord	64.4 m	13
Gerronostroma septentrionalis	110-264	Blue Fiord	39.6 m	12
Gerronostroma septentrionalis	110-156	Blue Fiord	11.4 m	3
Gerronostroma septentrionalis	110-342	Blue Fiord	lower 100 m	27
Gerronostroma septentrionalis	110-308	Eids	uppermost	23
Petridiostroma sp.	111-1	Blue Fiord	base upper mem.	27
Atelodictyon cf. *A. solidum*	120-6	Blue Fiord	±100 m	25
Pseudoactinodictyon conglutinatum	111-19	Bird Fiord	near base	20
Stictostroma gorriense	110-195	Blue Fiord	0 m	8
Stictostroma gorriense	111-1	Blue Fiord	upper mem.	27
Stictostroma gorriense	111-17	Blue Fiord	upper mem.	27
Stictostroma? nunavutense	110-111	Blue Fiord	±20 m	2
Stictostroma? nunavutense	110-180	Blue Fiord	lower 100 m	4
Stictostroma? nunavutense	110-190	Blue Fiord	lower 100 m	4
Stromatoporella perannulata	110-236	Blue Fiord	73.5 m	22
Stromatoporella perannulata	120-3	Blue Fiord	163 m	24
Stromatoporella perannulata	120-7	Blue Fiord	175 m	25
Clathrocoilona vexata	110-152	Blue Fiord	11.4 m	3
Clathrocoilona vexata	110-182	Blue Fiord	35 m	6
Clathrocoilona vexata	110-322	Blue Fiord	70.3 m	27
Clathrocoilona vexata	110-331	Blue Fiord	70.3 m	27
Clathrocoilona vexata	110-356	Blue Fiord	104.7 m	10
Clathrocoilona vexata	110-362	Blue Fiord	104.7 m	10
Stromatopora polaris	110-117	Blue Fiord	±100 m	2
Stromatopora polaris	110-120	Blue Fiord	±100 m	2
Stromatopora polaris	110-129	Blue Fiord	29.4 m	2

Appendix 3.—Continued.

Species	*specimen no.*	*formation*	*interval*	*location*
Stromatopora polaris	110-139	Blue Fiord	154.4 m	2
Stromatopora polaris	110-143	Blue Fiord	±10 m	3
Stromatopora polaris	110-153	Blue Fiord	63.2 m	3
Stromatopora polaris	110-160	Blue Fiord	63.2 m	3
Stromatopora polaris	110-184	Blue Fiord	±15 m	1
Stromatopora polaris	110-202	Blue Fiord	86.7 m	8
Stromatopora polaris	110-213	Blue Fiord	71.8 m	6
Stromatopora polaris	110-225	Blue Fiord	1403.3 m	5
Stromatopora polaris	110-231	Blue Fiord	1200.3 m	5
Stromatopora polaris	110-233	Blue Fiord	64.4 m	13
Stromatopora polaris	110-251	Blue Fiord	39.6 m	12
Stromatopora polaris	110-252	Blue Fiord	—	21
Stromatopora polaris	110-274	Blue Fiord	1403.3 m	5
Stromatopora polaris	110-286	Blue Fiord	44.5 m	15
Stromatopora polaris	110-299	Blue Fiord	1200.3 m	5
Stromatopora polaris	110-305	Blue Fiord	85.6 m	10
Stromatopora polaris	110-314	Blue Fiord	137.9 m	19
Stromatopora polaris	110-317	Eids	78.8 m below top	17
Stromatopora polaris	110-318	Eids	67.2 m below top	17
Stromatopora polaris	110-320	Blue Fiord	79.1 m	10
Stromatopora polaris	110-324	Blue Fiord	75.9 m	27
Stromatopora polaris	110-333	Blue Fiord	70.3 m	27
Stromatopora polaris	110-338	Eids	65 m below top	17
Stromatopora polaris	110-343	Eids	67.2 m below top	17
Stromatopora polaris	110-347	Blue Fiord	53.8 m	11
Stromatopora polaris	110-354	Blue Fiord	79.1 m	10
Stromatopora polaris	110-367	Eids	85.4 m below top	17
Stromatopora polaris	110-368	Blue Fiord	53.8 m	11
Stromatopora polaris	129-2	Disappointment Bay	basal	34
Stromatopora polaris	129-6	Disappointment Bay	basal	34
Stromatopora polaris	129-7	Disappointment Bay	basal	34
Stromatopora polaris	129-22	Disappointment Bay	basal	34
Stromatopora cf. *S. hupschii*	110-166	Blue Fiord	63.2 m	3
Stromatopora cf. *S. hupschii*	110-291	Blue Fiord	66.2 m	29
Stromatopora cf. *S. hupschii*	110-304	Eids	71.7 m below top	17
Glyptostromoides simplex	110-113	Blue Fiord	8.9 m	2
Glyptostromoides simplex	110-201	Blue Fiord	77.1 m	7
Glyptostromoides simplex	110-319	Blue Fiord	146.6 m	10
Glyptostromoides simplex	110-329	Blue Fiord	146.6 m	10
Glyptostromoides simplex	110-341	Eids	uppermost	23
Glyptostromoides simplex	110-353	Eids	uppermost	23
Glyptostromoides simplex	110-357	Blue Fiord	146.6 m	10
Glyptostromoides simplex	110-358	Blue Fiord	±50 m	9
Glyptostromoides simplex	110-359	Blue Fiord	66.3 m	11
Glyptostromoides simplex	110-371	Blue Fiord	21.0 m	9
Salairella prima	110-112	Blue Fiord	46.6 m	2
Salairella prima	110-125	Blue Fiord	11.4 m	3
Salairella prima	110-131	Blue Fiord	50.5 m	9
Salairella prima	110-134	Blue Fiord	154.4 m	2
Salairella prima	110-183	Eids	98.4 m below top	4
Salairella prima	110-188	Blue Fiord	154.1 m	1
Salairella prima	110-214	Blue Fiord	71.8 m	6
Salairella prima	110-237	Blue Fiord	86 m	15
Salairella prima	110-250	Blue Fiord	86 m	15
Salairella prima	110-254	Blue Fiord	86 m	15
Salairella prima	110-271	Blue Fiord	±100 m	18
Salairella prima	110-301	Blue Fiord	1403.3 m	5
Salairella prima	110-309	Blue Fiord	21 m	9
Salairella prima	110-316	Blue Fiord	146.6 m	10
Salairella prima	110-334	Blue Fiord	70.3 m	27
Salairella prima	110-337	Blue Fiord	70.0 m	6

Appendix 3.—Continued.

Species	*specimen no.*	*formation*	*interval*	*location*
Salairella prima	110-339	Eids	60.6 m below top	17
Salairella prima	110-345	Eids	±65 m below top	17
Salairella prima	110-348	Eids	60.6 m below top	17
Salairella prima	110-349	Eids	±65 m below top	17
Salairella prima	110-365	Blue Fiord	±50 m	9
Salairella prima	110-366	Blue Fiord	±100 m	32
Salairella prima	110-367	Eids	85.4 m below top	17
Salairella prima	129-28	Disappointment Bay	basal	34
Salairella prima	Lowther	Disappointment Bay	lower 50 m	33
Atopostroma distans	110-116	Blue Fiord	basal	2
Atopostroma distans	110-175	Blue Fiord	basal	16
Atopostroma distans	111-25	Bird Fiord	basal	20
Habrostroma proxilaminatum	129-3	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-4	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-5	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-8	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-12	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-14	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-15	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-17	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-19	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-23	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-24	Disappointment Bay	basal	34
Habrostroma proxilaminatum	129-27	Disappointment Bay	basal	34
Habrostroma proxilaminatum	110-215	unnamed	lower 100 m	36
Habrostroma proxilaminatum	110-226	unnamed	lower 100 m	36
Parallelopora campbelli	110-244	unnamed	lower 100 m	36
Parallelopora campbelli	110-278	unnamed	lower 100 m	36

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EXPLANATION OF PLATE 1

Figure Page

1–3. *Actinostroma* sp. A. 14

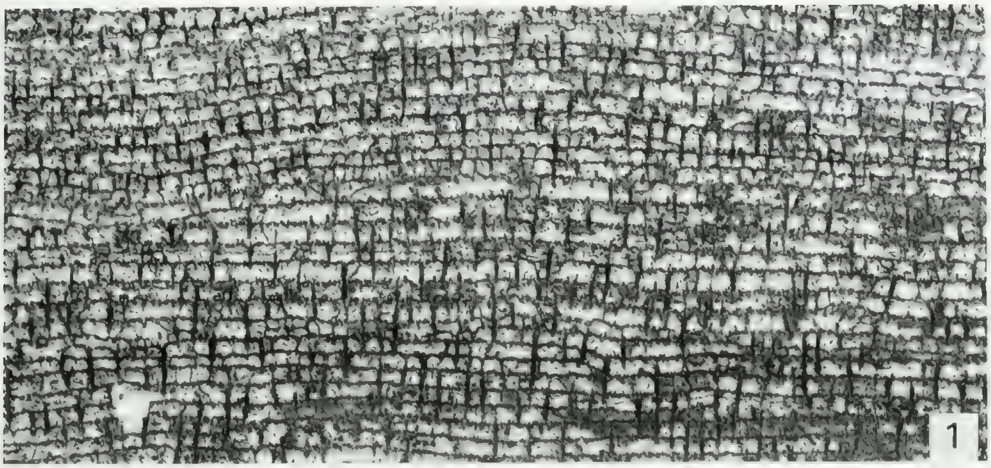
Specimen GSC 108852.

1. Vertical section; × 10.
2. Vertical section, detail of pillars diverging from low mamelon; × 10.
3. Tangential section; × 10.

4–5. *Plectostroma salairicum* (Yavorsky, 1930). 15

Specimen GSC 108853.

4. Vertical section; × 10.
5. Tangential section; × 10.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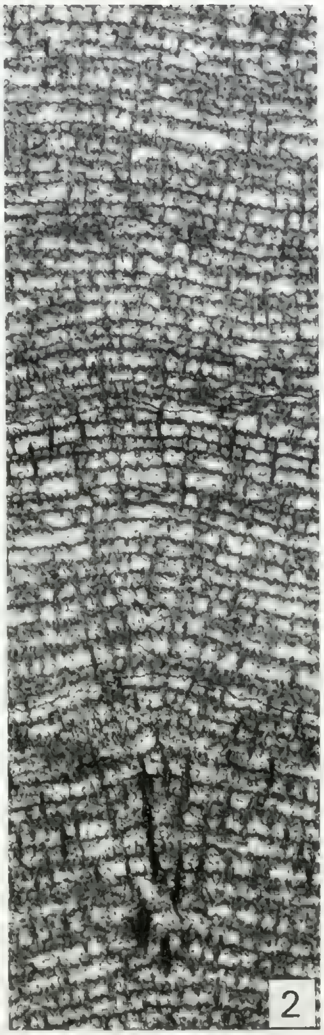
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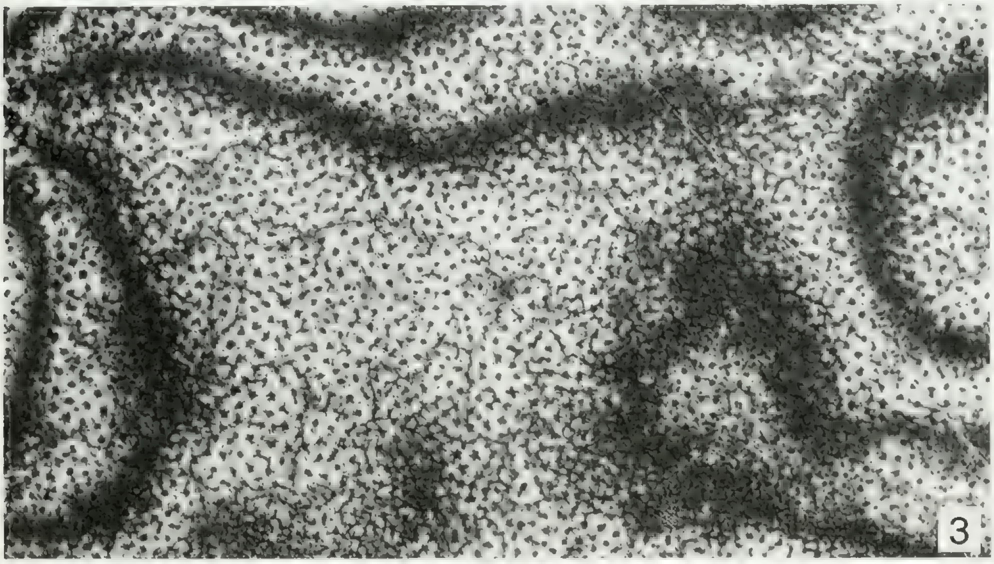
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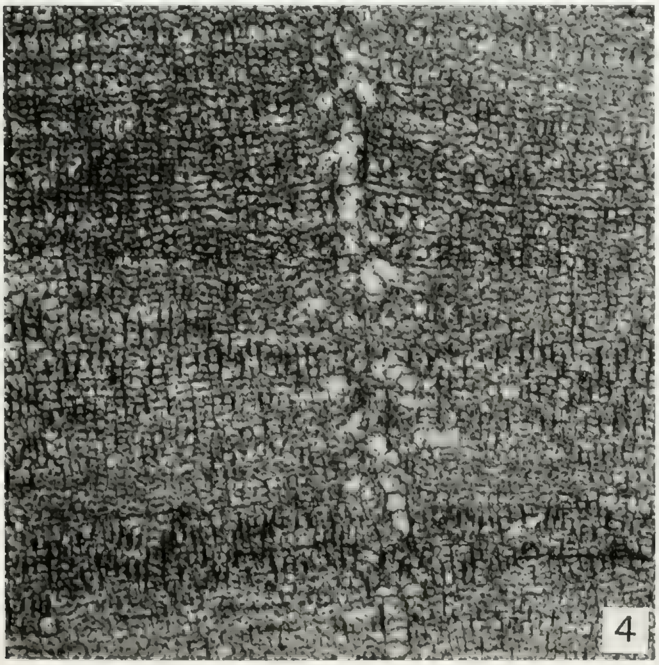
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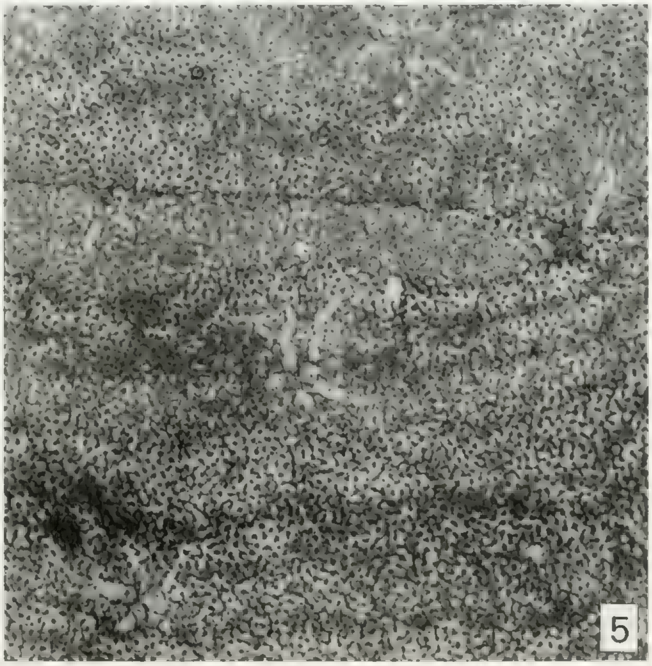
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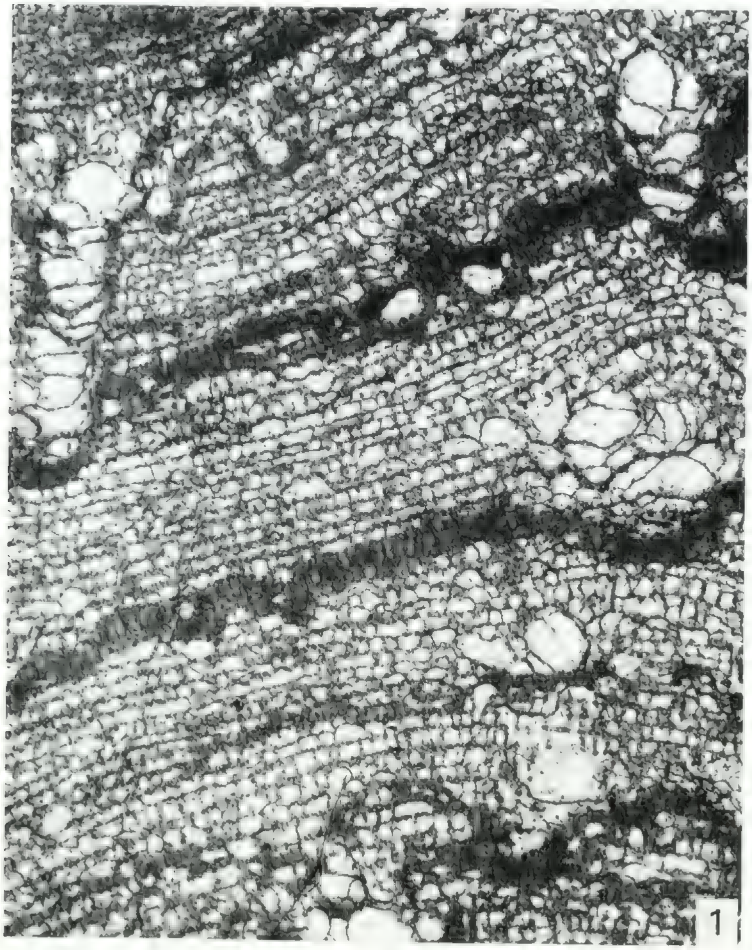
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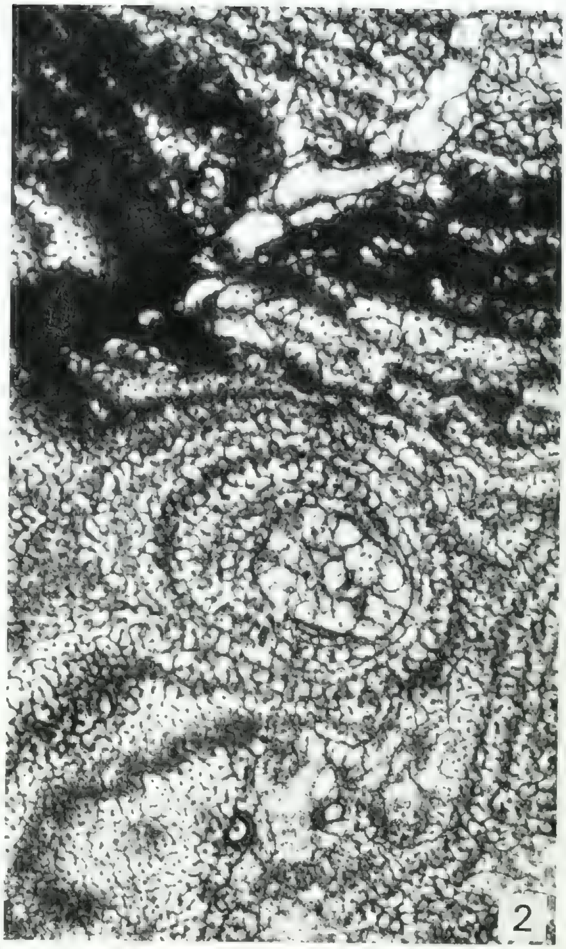
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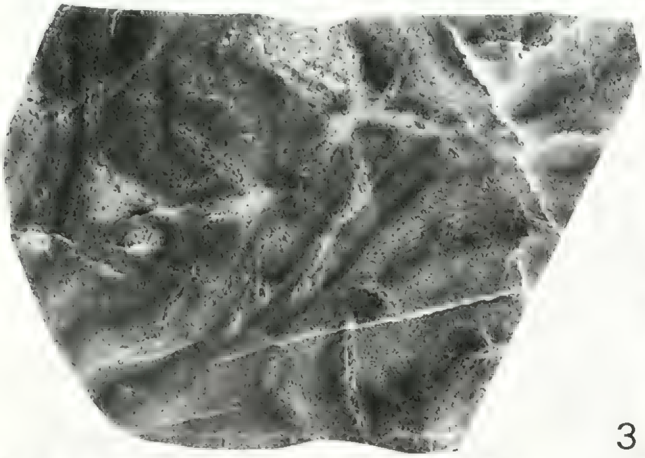
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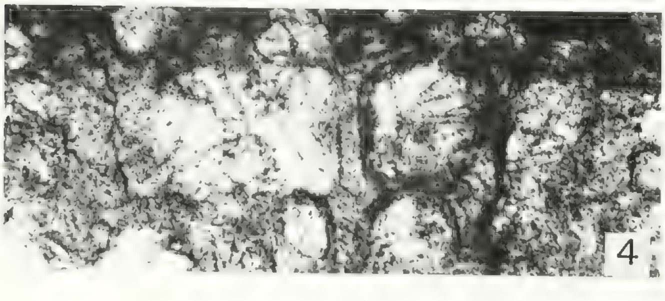
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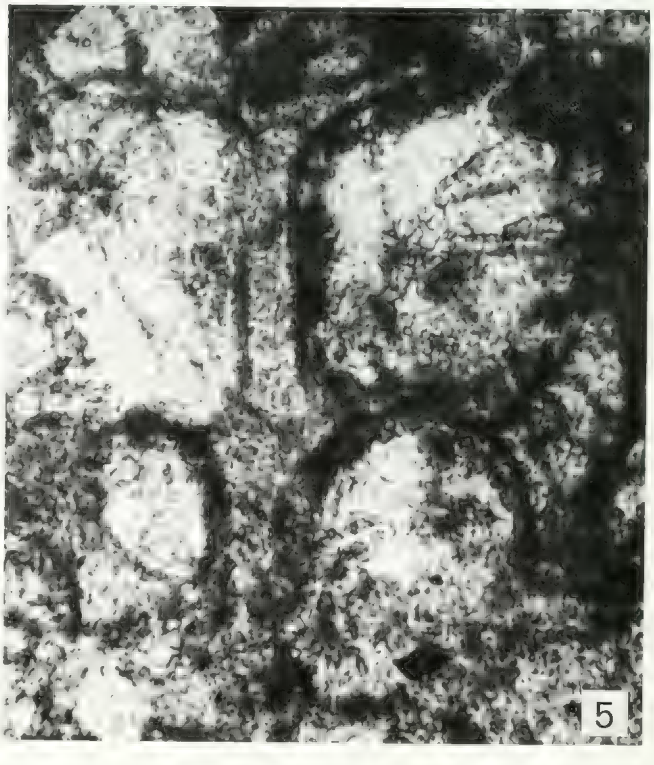
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EXPLANATION OF PLATE 2

Figure		Page
1–5.	*Aculatostroma* cf. *A. kaljanum* (Bogoyavlenskaya, 1977).	16

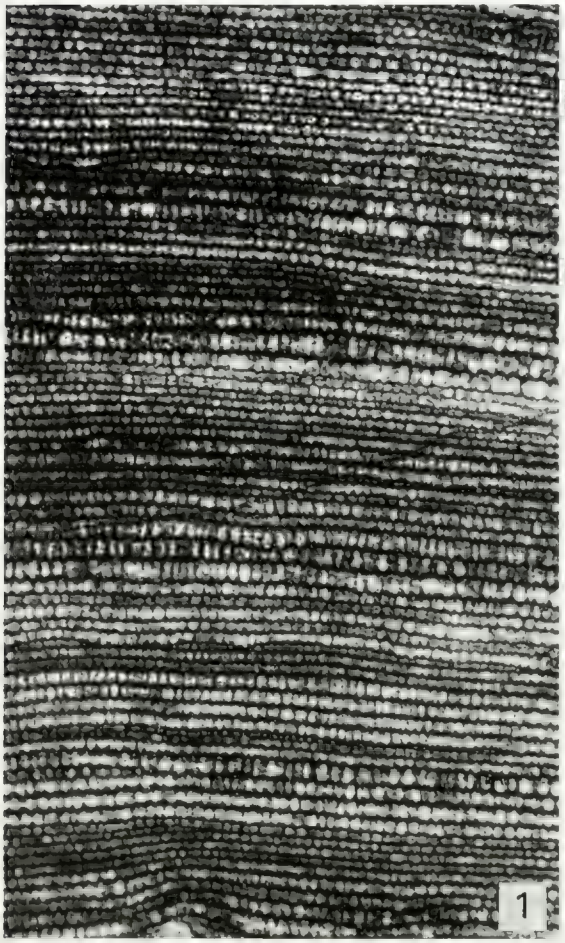
Specimen GSC 108855.

1. Vertical section; ×10.
2. Tangential section; ×10.
3. Hand-specimen, slabbed surface; ×2. Note pattern and distribution of astrorhizae.

4, 5. Vertical section, detail of colliculate pillars. Same view at ×100 (Fig. 4) and ×250 (Fig. 5).

EXPLANATION OF PLATE 3

Figure		Page
1–3.	*Clathrodictyon ellesmerense* Stearn, 1983.	17
	1. Vertical section; × 10. Specimen GSC 108857. Note successive phases of growth (rhythmic variation of laminar spacing).	
	2. Vertical section; × 10. Specimen GSC 108856.	
	3. Vertical section; × 6. Specimen GSC 108858. Note the impersistent protuberances, unlike mamelons.	
4–5.	*Gerronostroma septentrionalis*, new species.	18
	Paratype GSC 108860.	
	4. Vertical section; × 10.	
	5. Tangential section; × 10.	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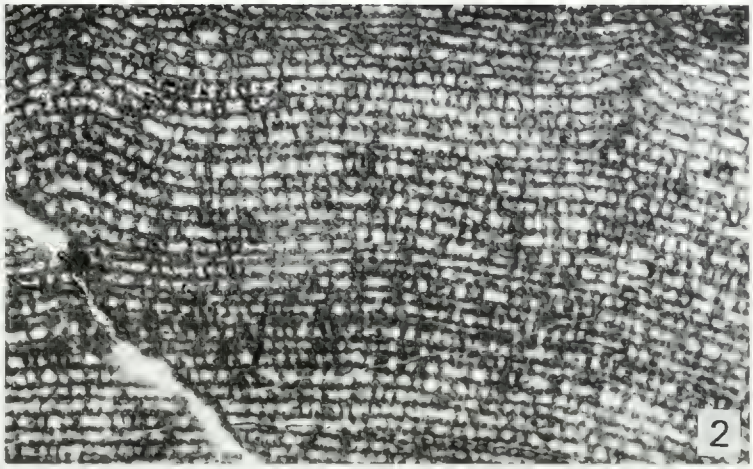
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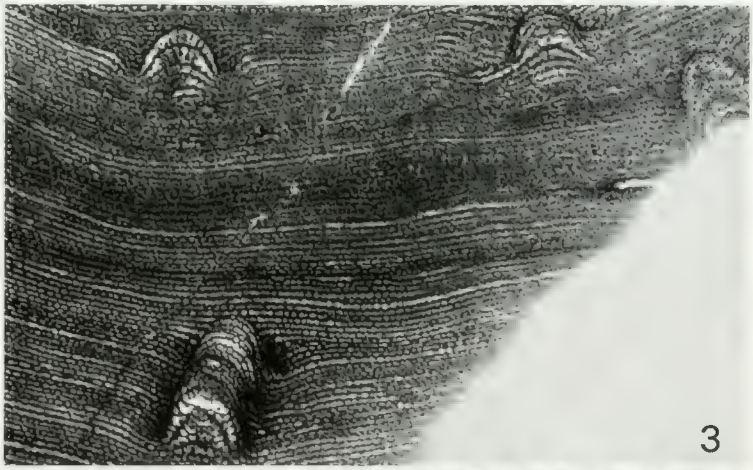
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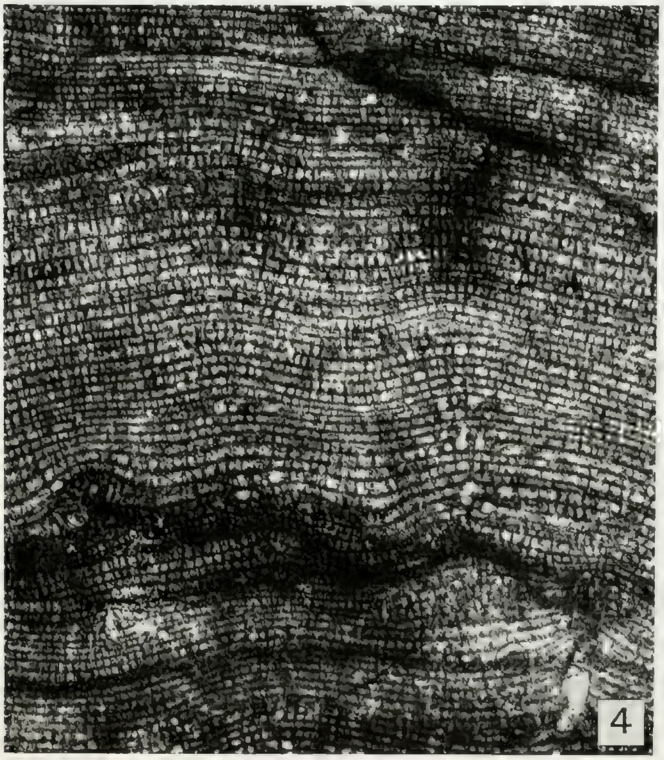
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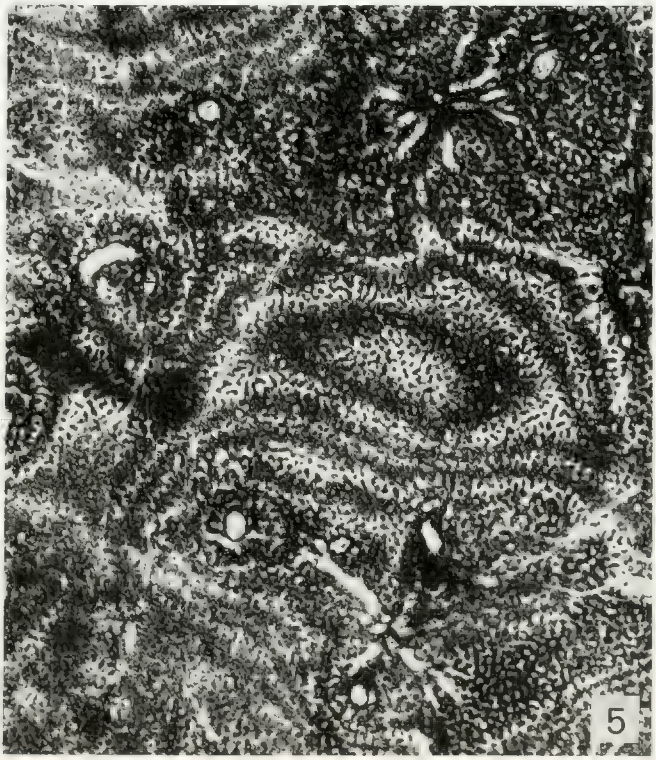
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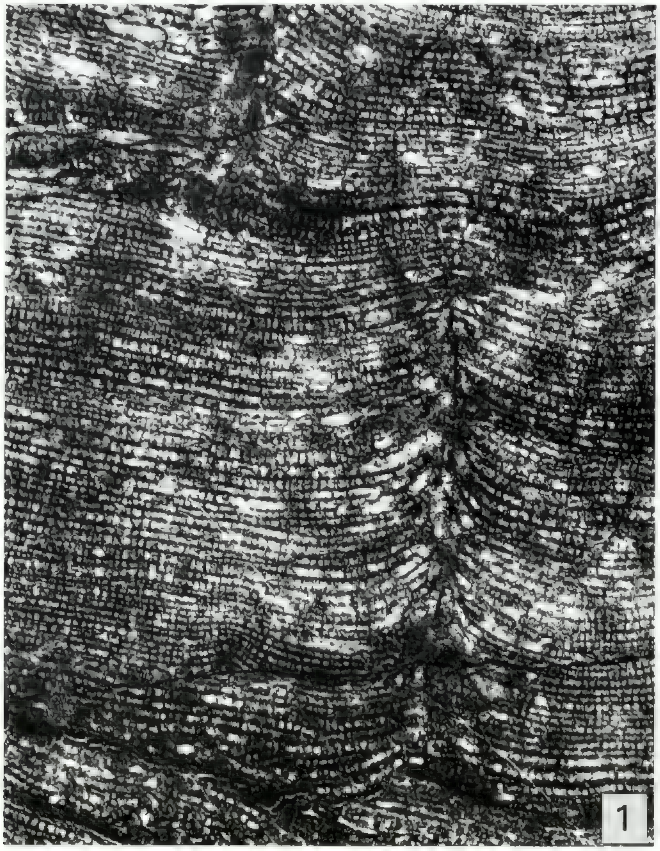
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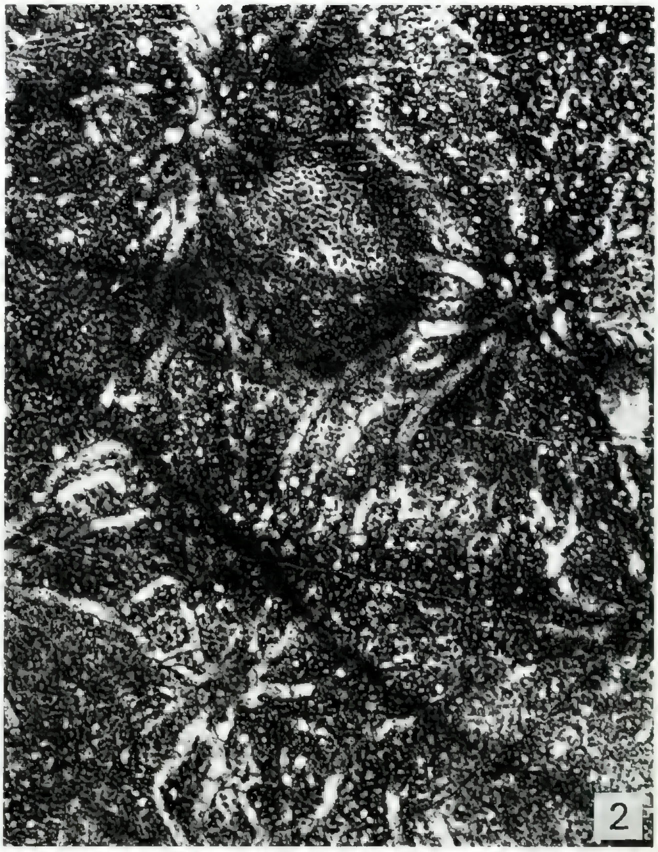
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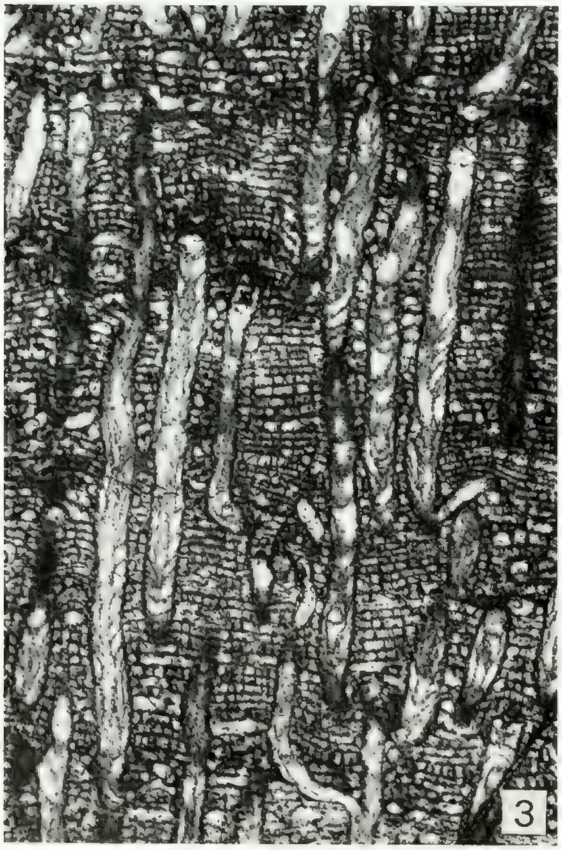
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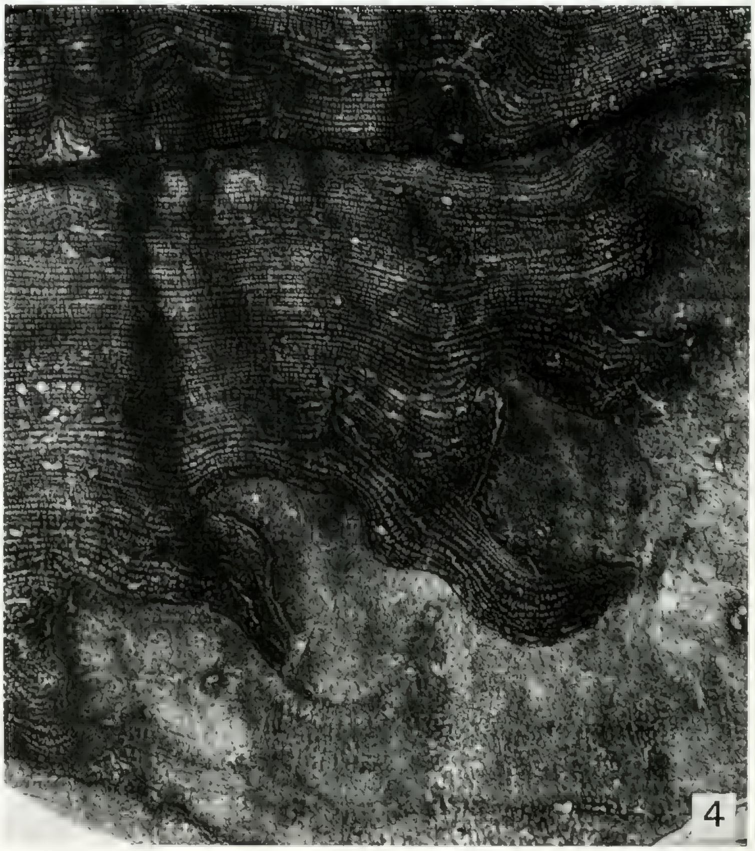
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EXPLANATION OF PLATE 4

Figure	Page
1–4. *Gerronostroma septentrionalis,* new species.	18

1, 2. Holotype GSC 108859. Vertical section (Fig. 1) and tangential section (Fig. 2); ×10.

3. Paratype GSC 108862. Vertical section; ×10. Note abundant commensal syringoporids.

4. Competitive overgrowth relationship between holotype *G. septentrionalis* n. sp. (left, upper) and *Stromatopora polaris* (right, lower). GSC 108859. Vertical section; ×5.

EXPLANATION OF PLATE 5

Figure Page

1, 2. *Petridiostroma* sp. 19

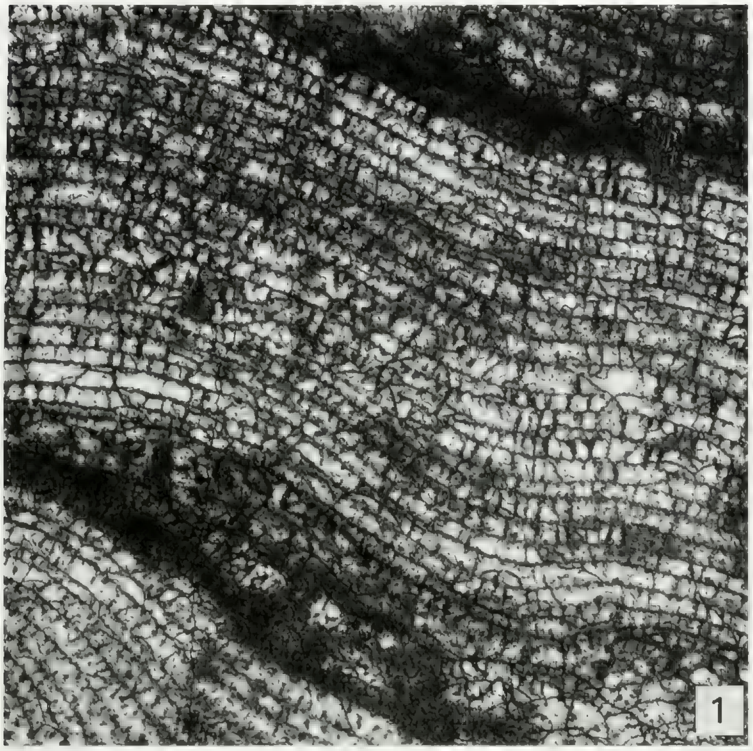
Specimen GSC 108863.

1. Vertical section; ×10.
2. Tangential section; ×10.

3, 4. *Atelodictyon* cf. *A. solidum* Khromych, 1976. 20

Specimen GSC 108865. Note: thin-sections photographed under reflected light.

3. Vertical section; ×10.
4. Tangential section; ×10.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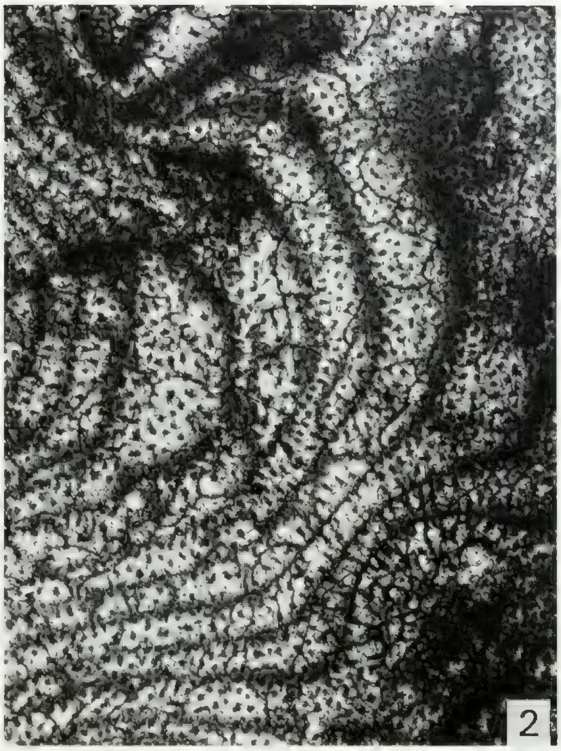
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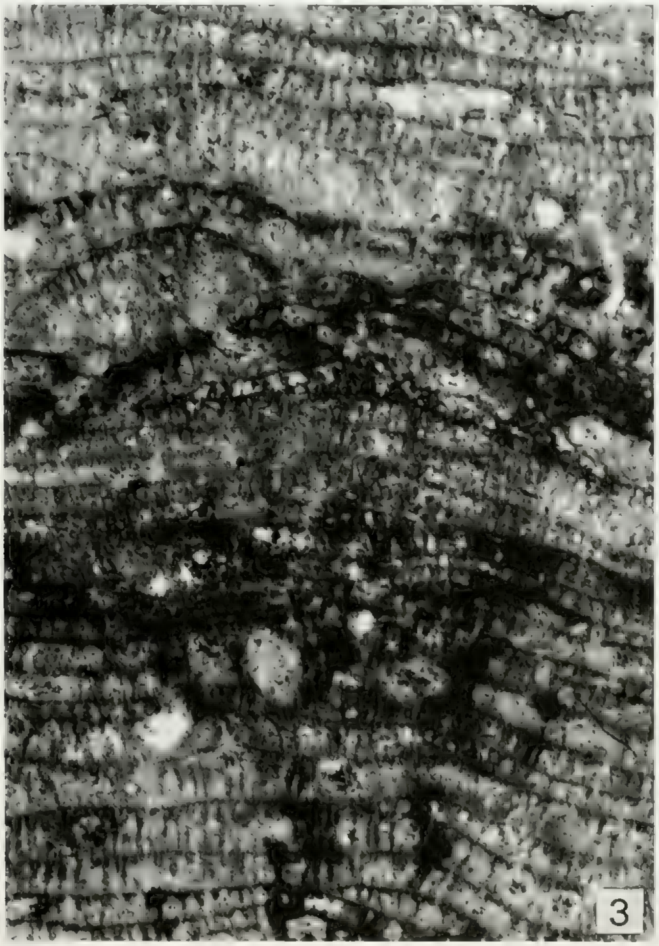
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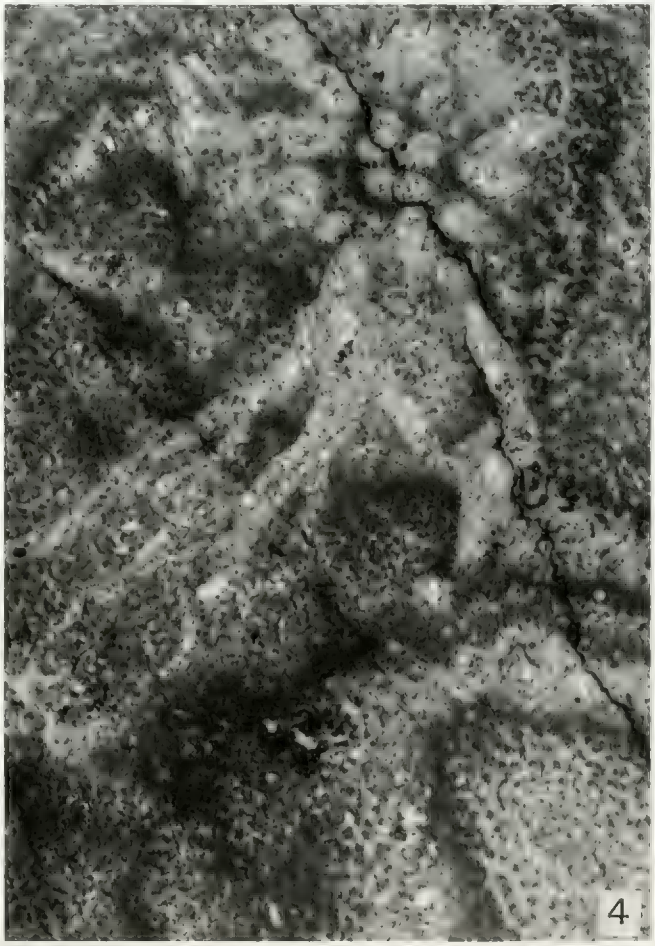
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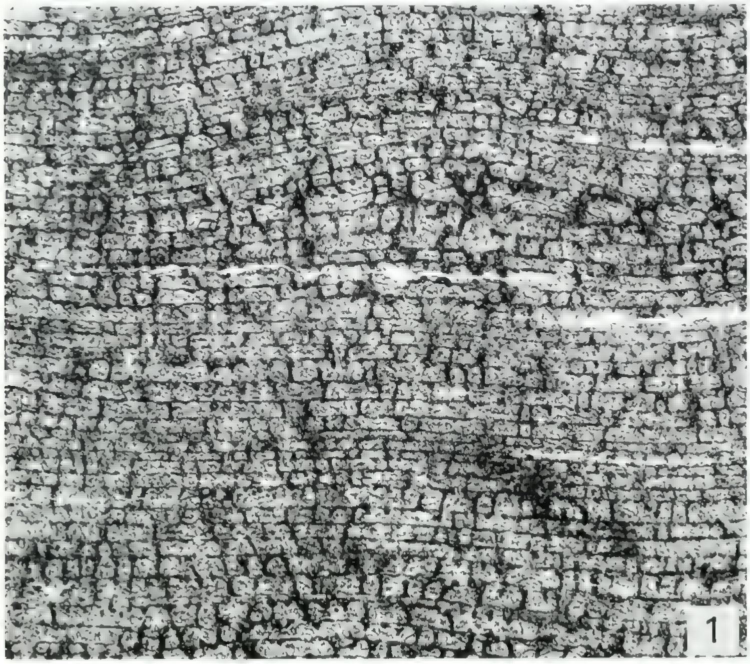
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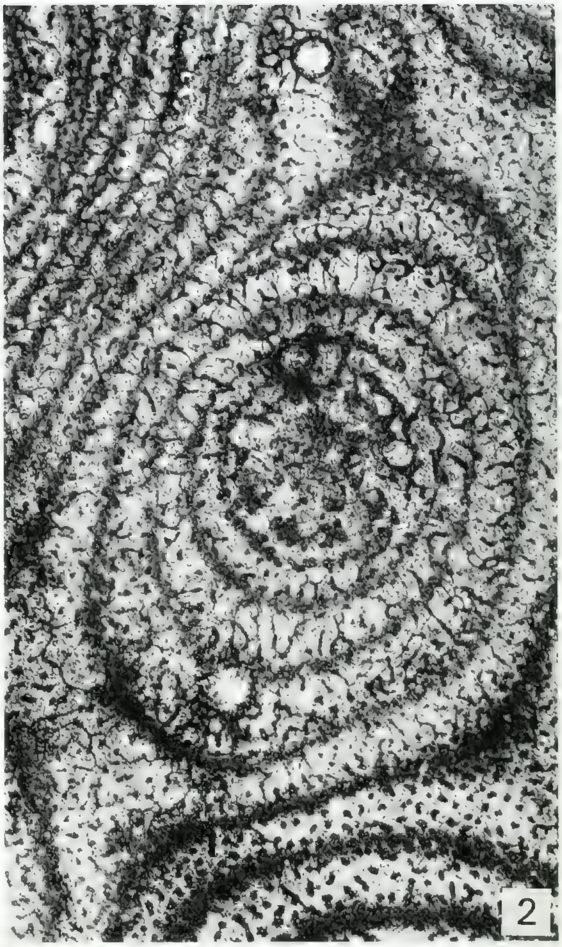
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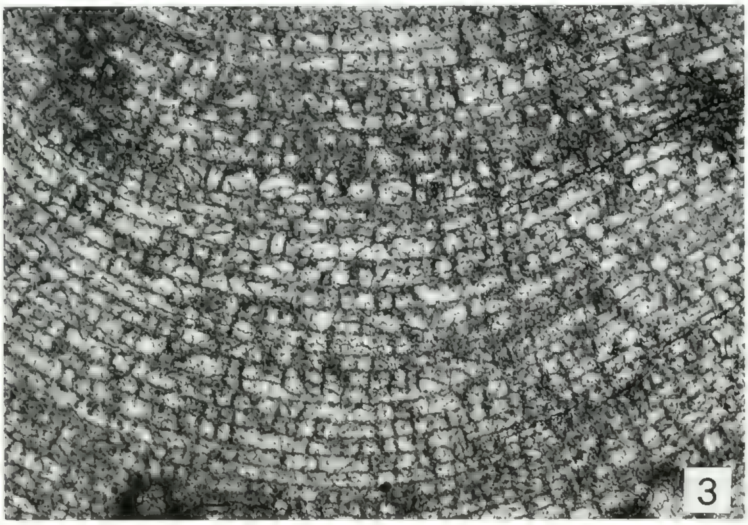
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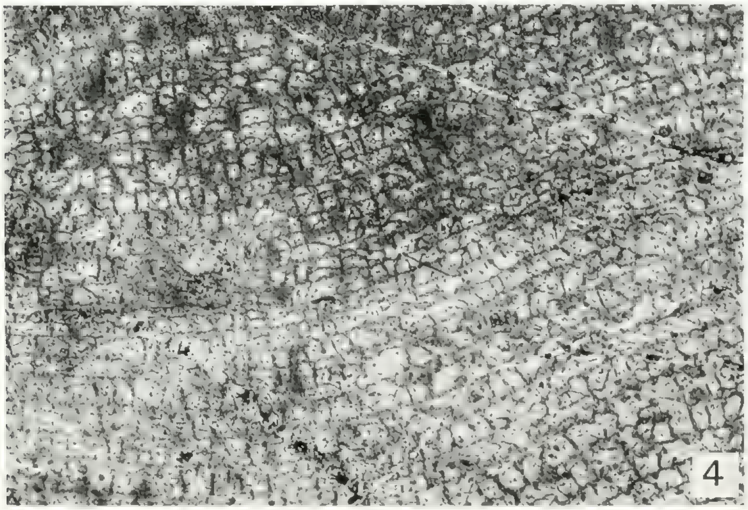
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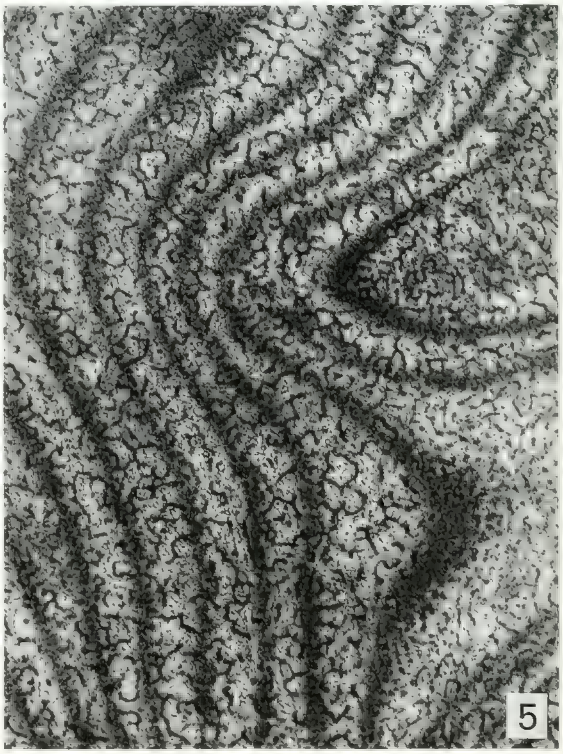
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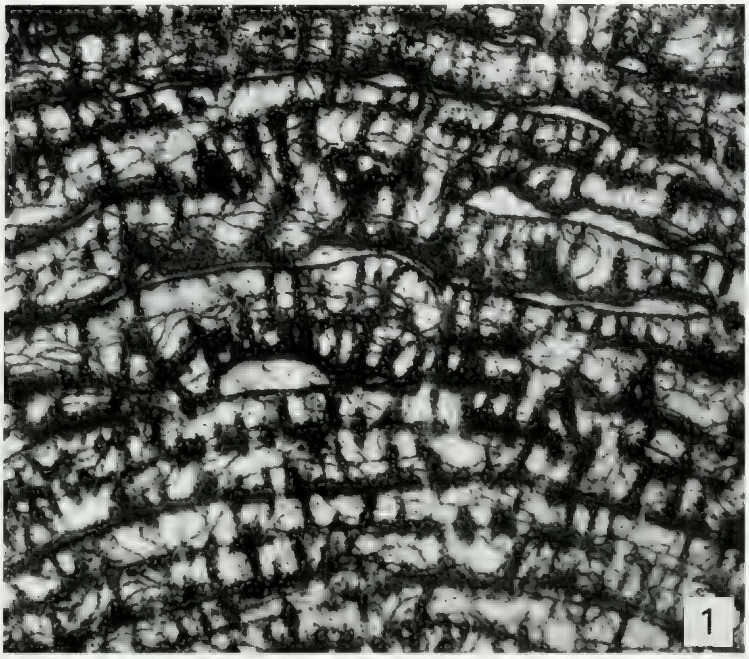
EXPLANATION OF PLATE 6

Figure		Page
1–5.	*Anostylostroma anfractum,* new species.	21

1. Holotype GSC 108866. Vertical section; ×10.
2. Holotype GSC 108866. Tangential section; ×10.
3. Paratype GSC 108867. Vertical section; ×10.
4. Paratype GSC 108869. Vertical section; ×10.
5. Paratype GSC 108868. Tangential section; ×10.

EXPLANATION OF PLATE 7

Figure		Page
1–4.	*Pseudoactinodictyon conglutinatum,* new species.	22
	1. Holotype GSC 108870. Vertical section; × 10.	
	2. Holotype GSC 108870. Tangential section; × 10.	
	3. Paratype GSC 108871. Vertical section; × 10.	
	4. Paratype GSC 108871. Tangential section; × 10.	
5–6.	*Schistodictyon*? sp.	23
	Specimen GSC 108872.	
	5. Vertical section; × 10.	
	6. Tangential section; × 10.	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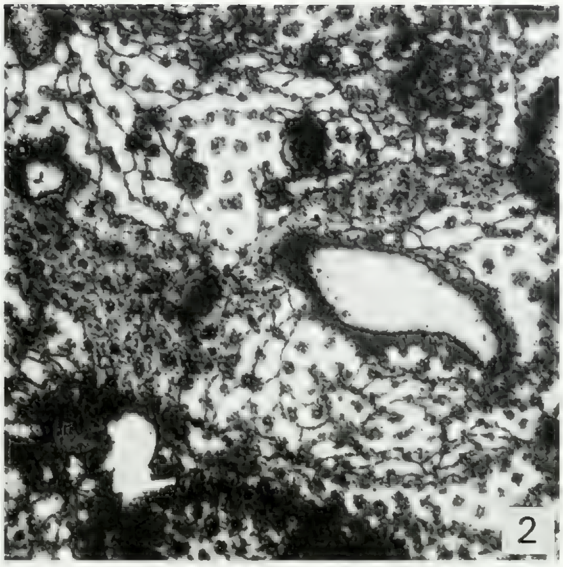
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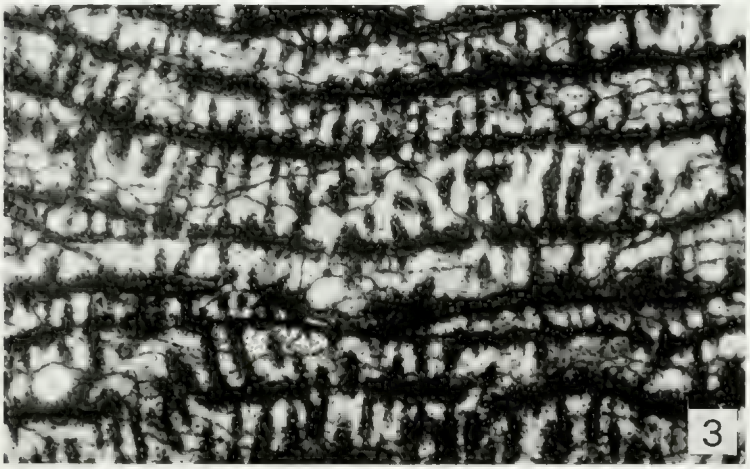
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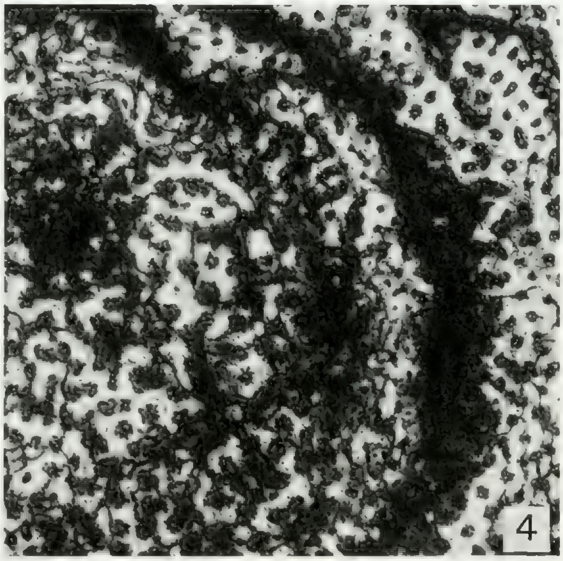
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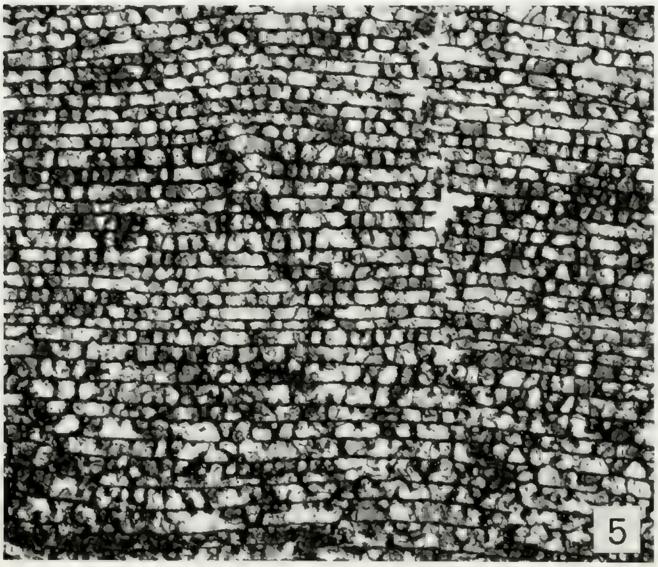
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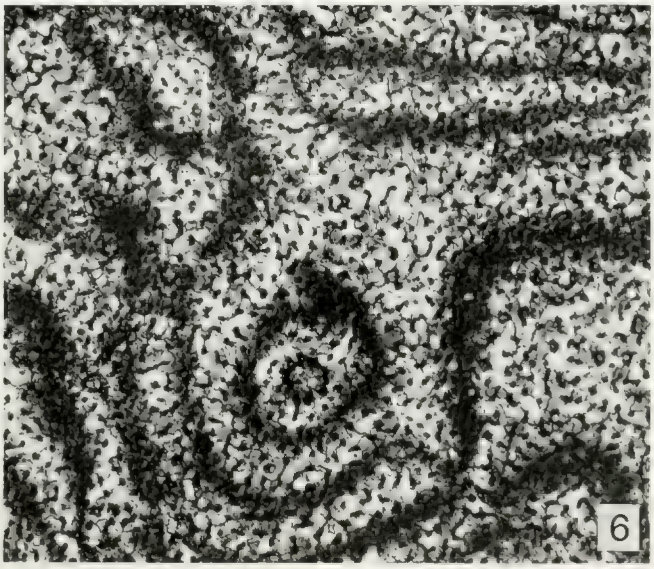
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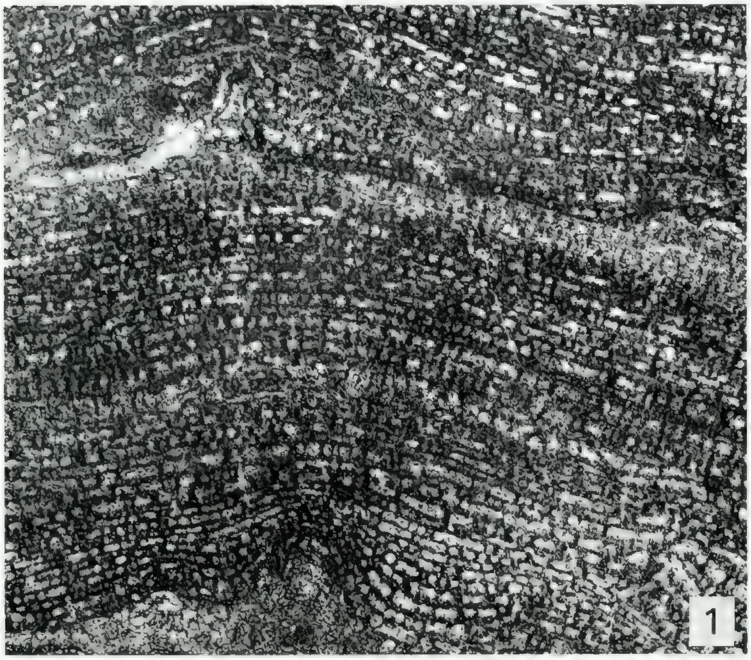
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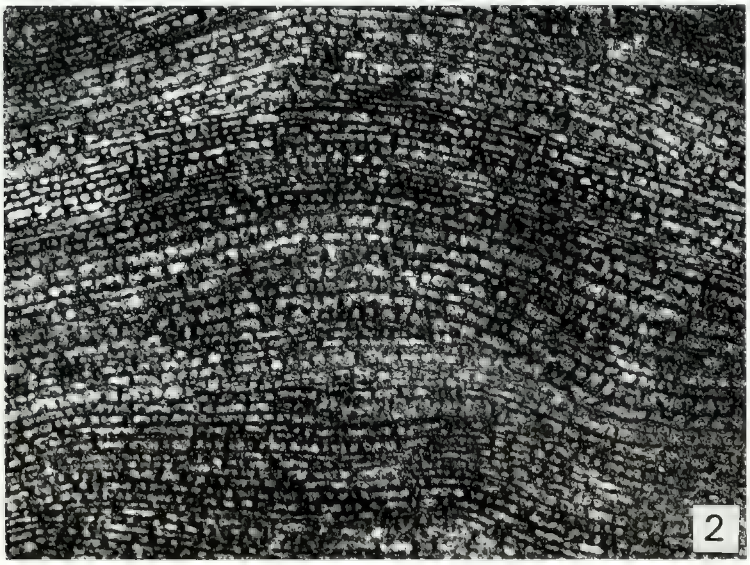
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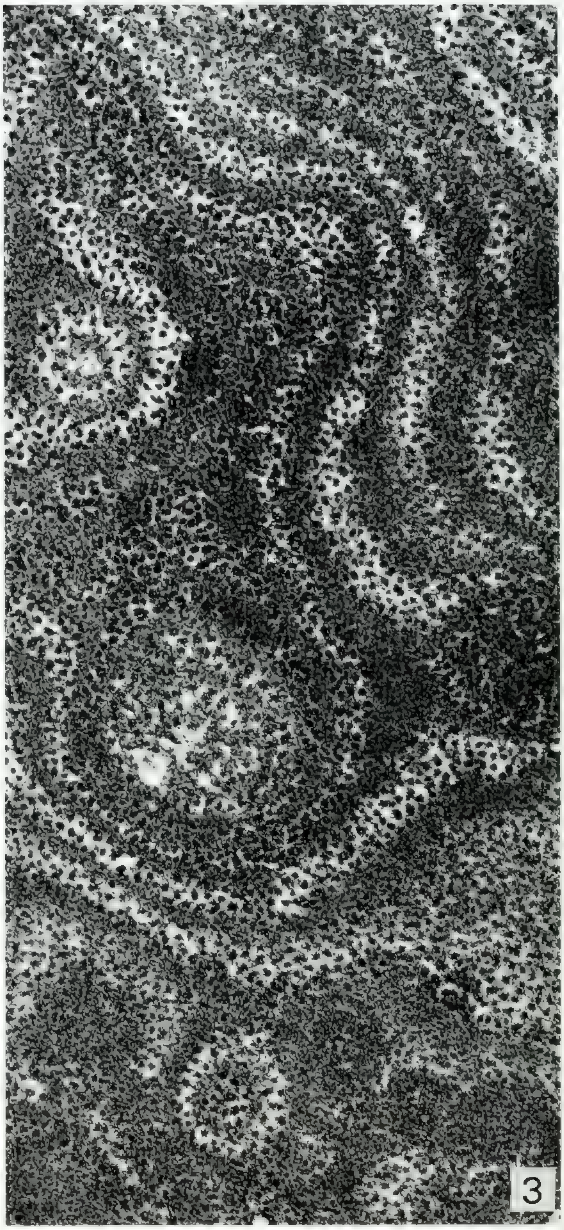
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4

5

EXPLANATION OF PLATE 8

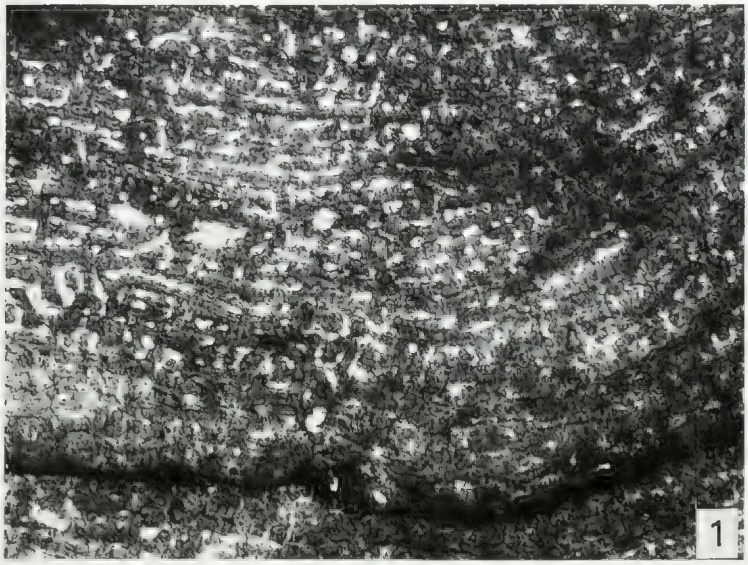
Figure		Page
1–5.	*Stictostroma gorriense* Stearn, 1995.	24

1. Vertical section; ×10. Specimen GSC 108177.
2. Vertical section; ×10. Specimen GSC 108874
3. Tangential section; ×10. Specimen GSC 108177.
4. Vertical section, detail of microstructure; ×50. Specimen GSC 108874.
5. Tangential section, detail of microstructure; ×50. Specimen GSC 108875.

EXPLANATION OF PLATE 9

Figure		Page
1–5.	*Stictostroma*? *nunavutense*, new species.	25

1. Holotype GSC 108876. Vertical section; ×10.
2. Paratype GSC 108877. Vertical section; ×10.
3. Holotype GSC 108876. Tangential section; ×10.
4. Vertical section, detail of microstructure; ×25. Paratype GSC 108877.
5. Tangential section, detail of microstructure; ×25. Paratype GSC 108877.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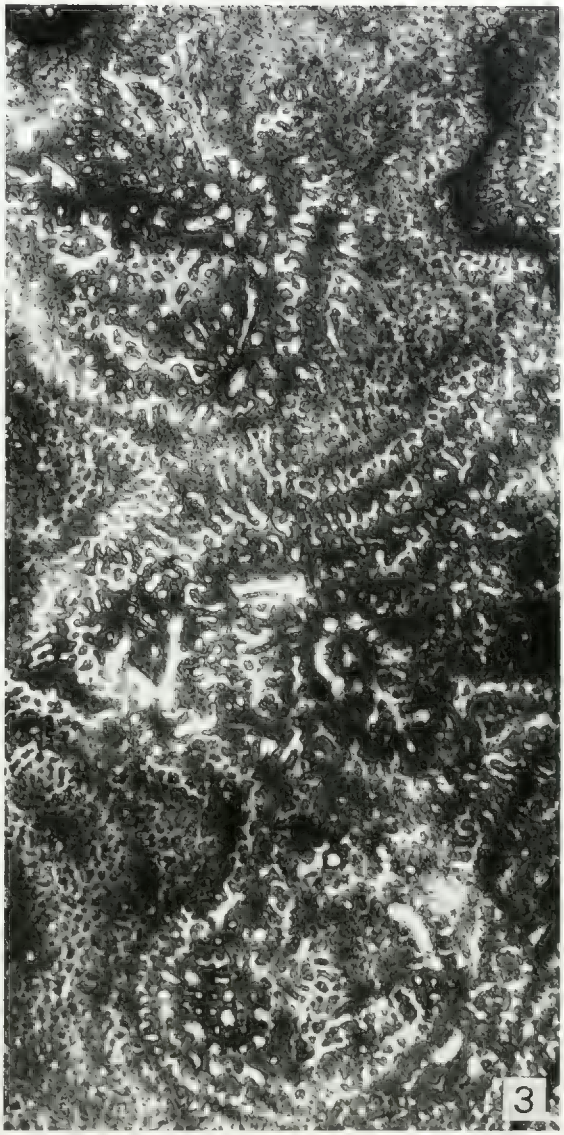
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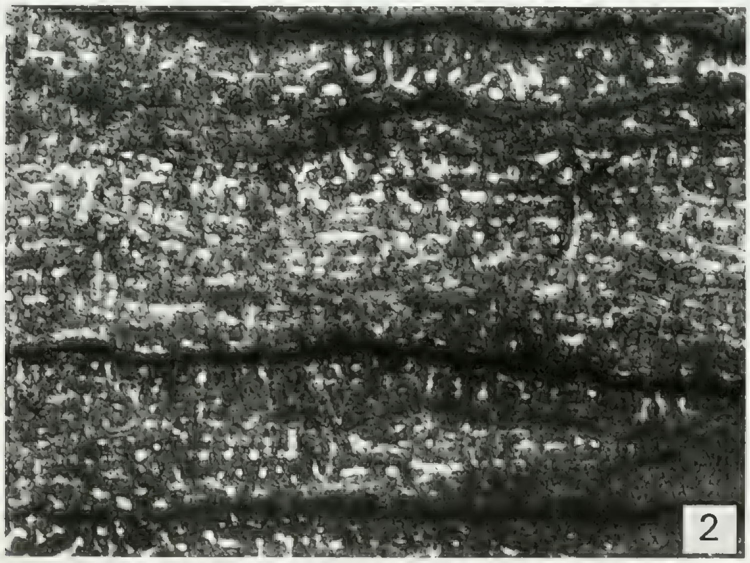
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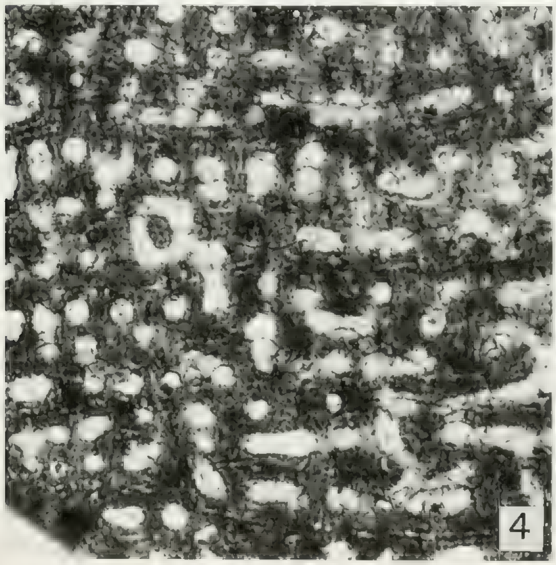
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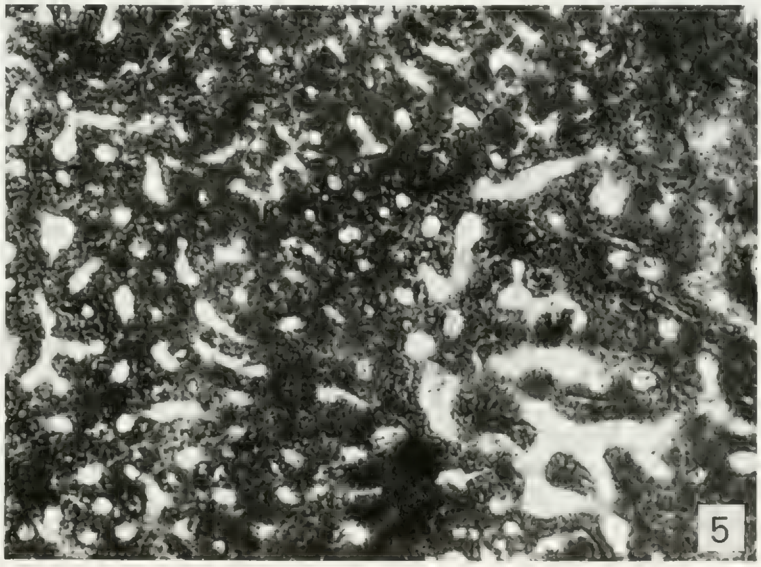
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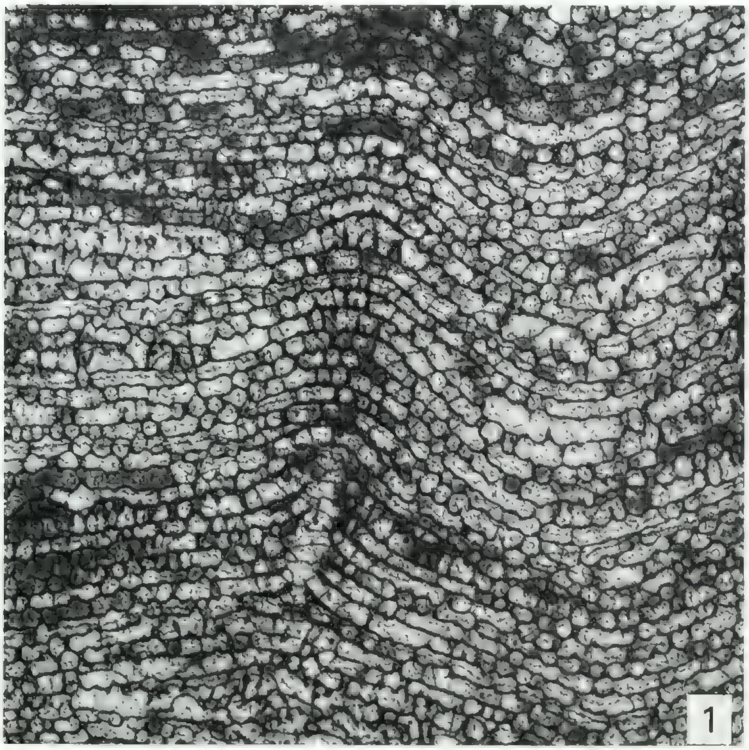
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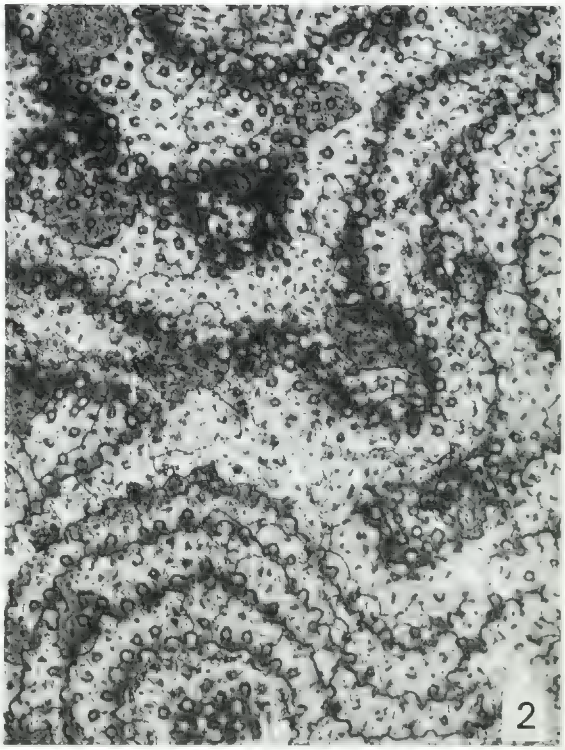
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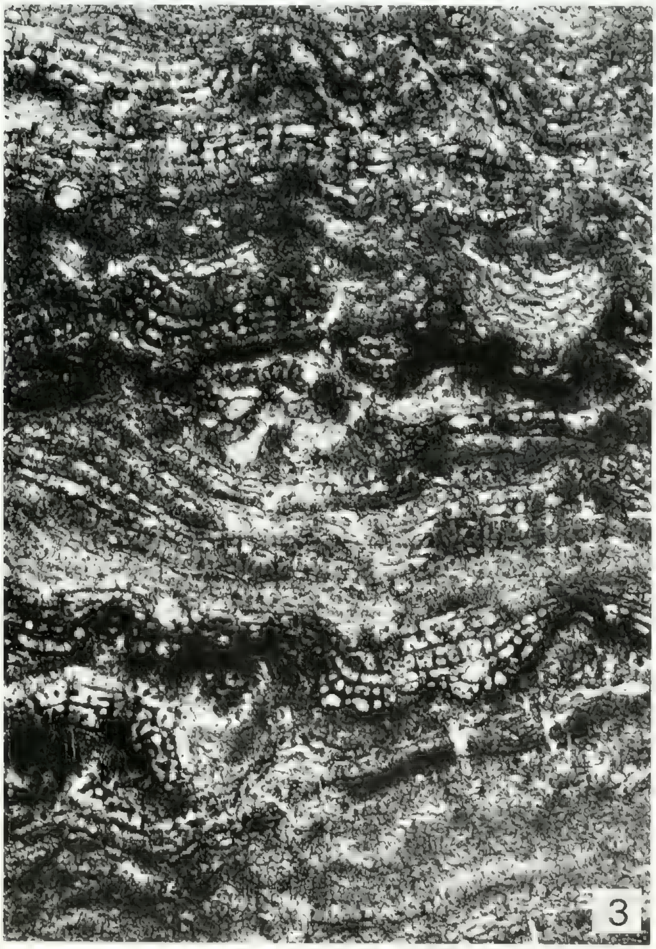
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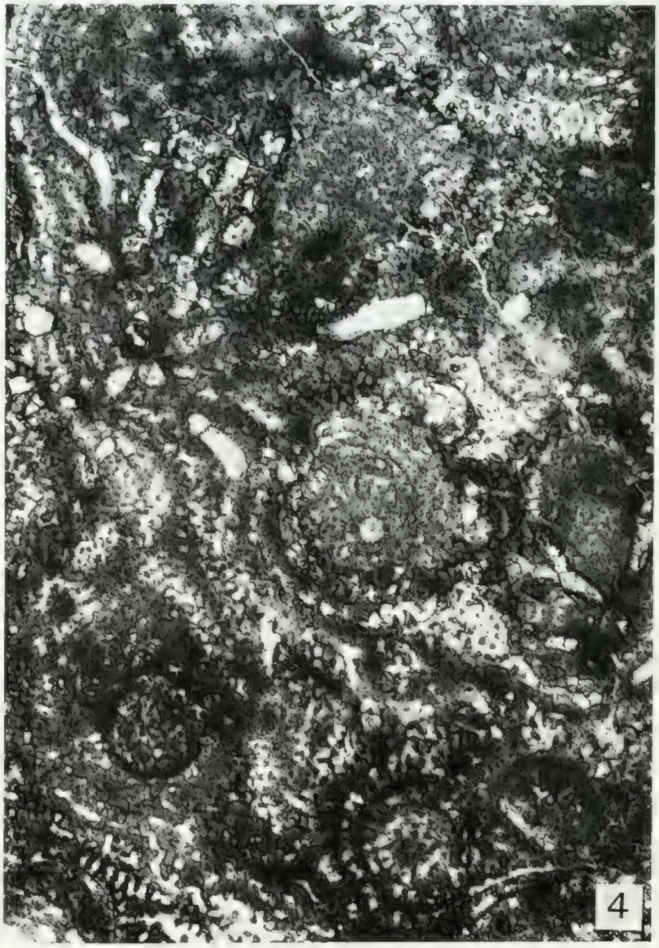

4

EXPLANATION OF PLATE 10

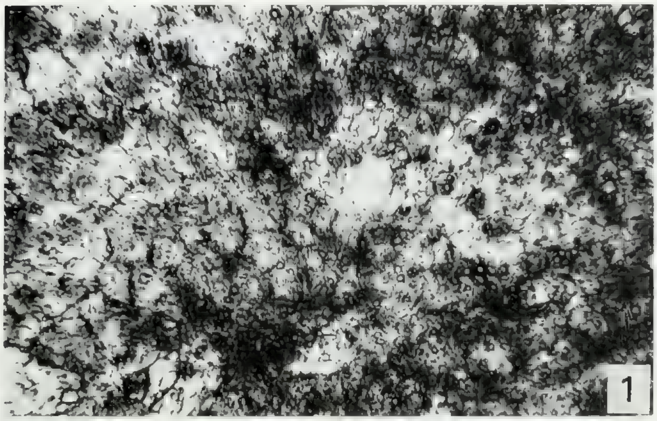
Figure | Page
1, 2. *Stromatoporella perannulata* Galloway and St. Jean, 1957. 26
Specimen GSC 108175.
  1. Vertical section; ×10.
  2. Tangential section; ×10.
3, 4. *Clathrocoilona vexata*, new species. 28
Holotype GSC 108881.
  3. Vertical section; ×10.
  4. Tangential section; ×10.

EXPLANATION OF PLATE 11

Figure		Page
1–8.	*Clathrocoilona vexata*, new species.	28

Detail of microstructures; all figures ×50.

1. Tubulate microstructure; tangential section. Holotype GSC 108881.
2. Tubulate microstructure; vertical section. Paratype GSC 108883.
3. Tubulate microstructure; vertical section. Holotype GSC 108881.
4. Vermiculated or felted microstructure; vertical section. Paratype GSC 108883.
5. Compact microstructure; vertical section. Paratype GSC 108883.
6. Blocky or melanospheric microstructure; vertical section. Paratype GSC 108882.
7. Melanospheric microstructure; tangential section. Paratype GSC 108882.
8. Ordinicellular microstructure (centre of field); vertical section. Holotype GSC 108881.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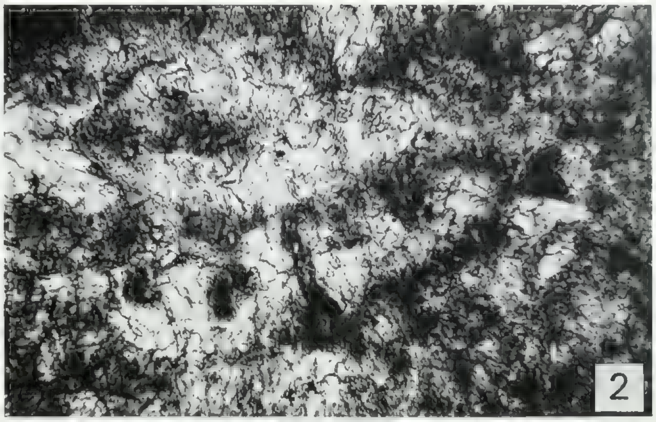
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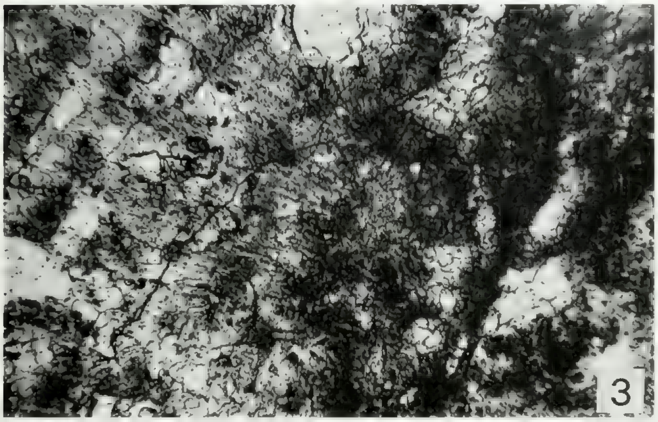
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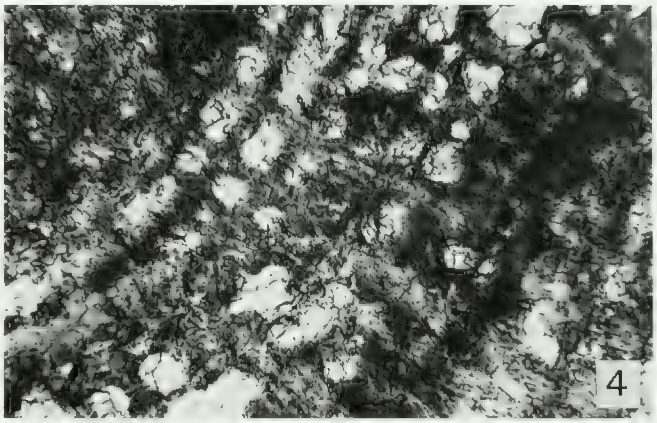
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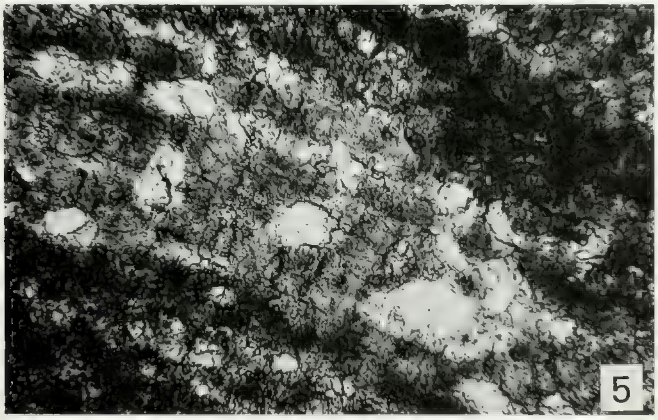
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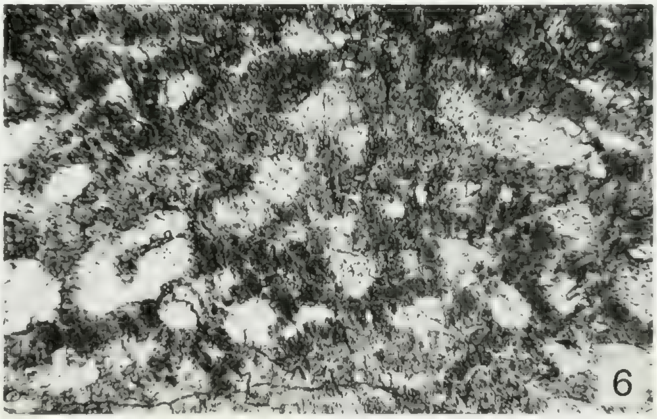
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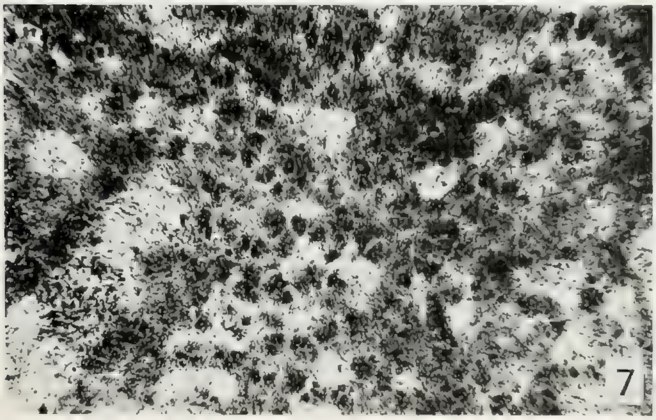
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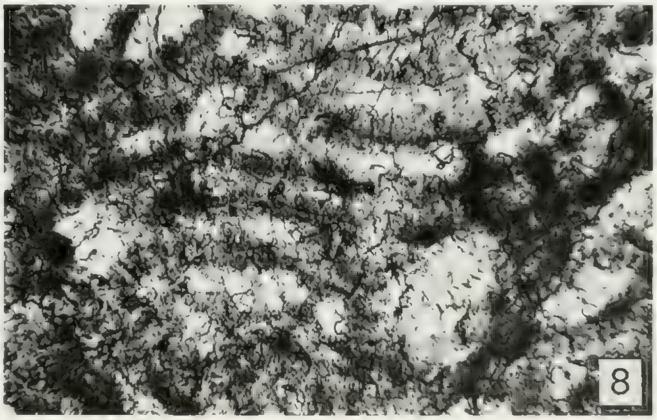
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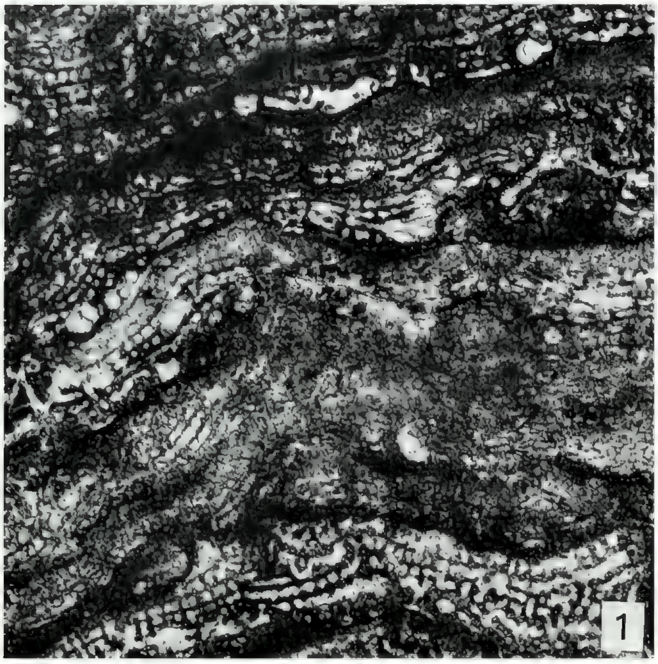
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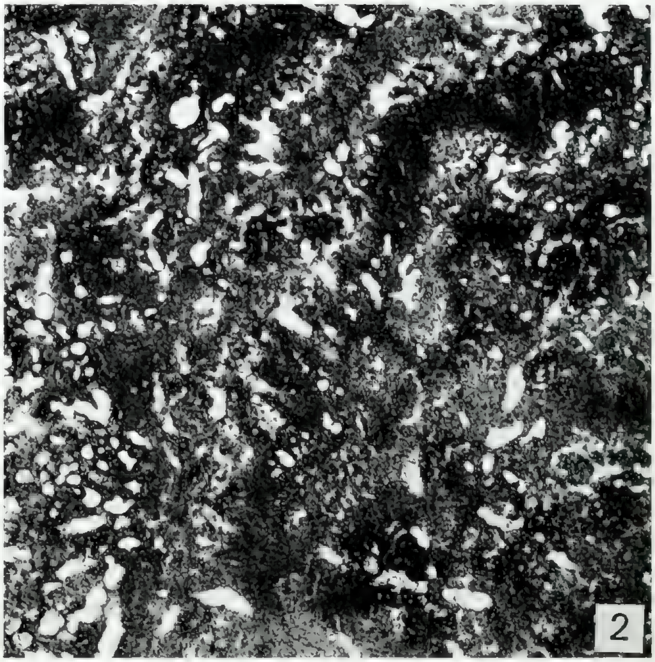
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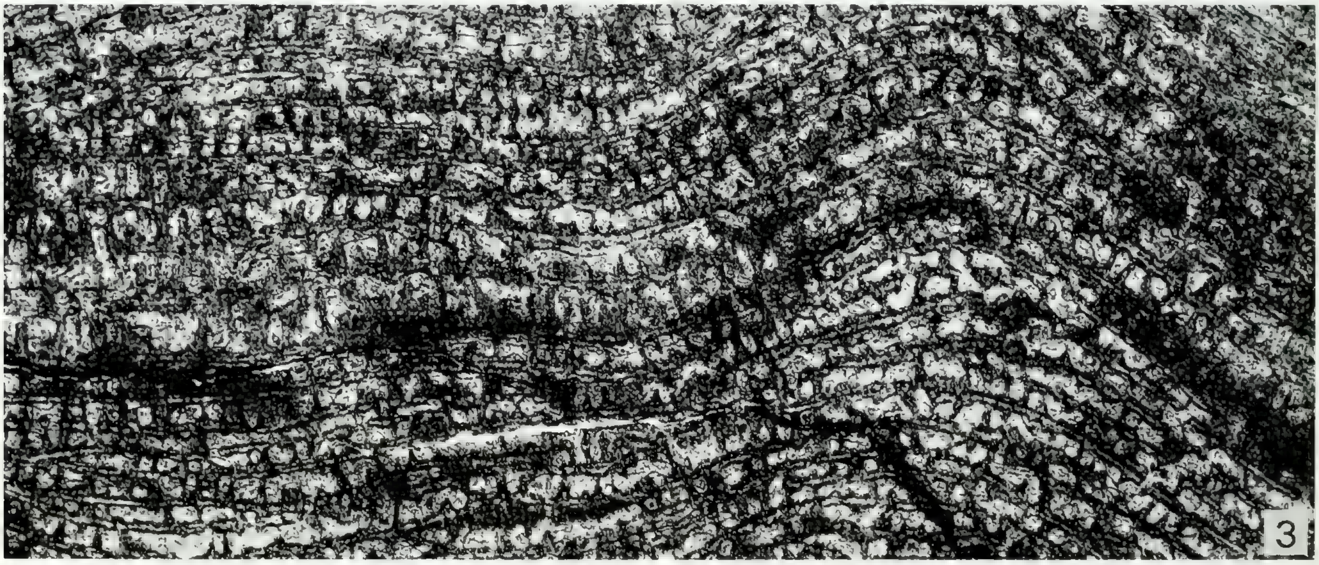
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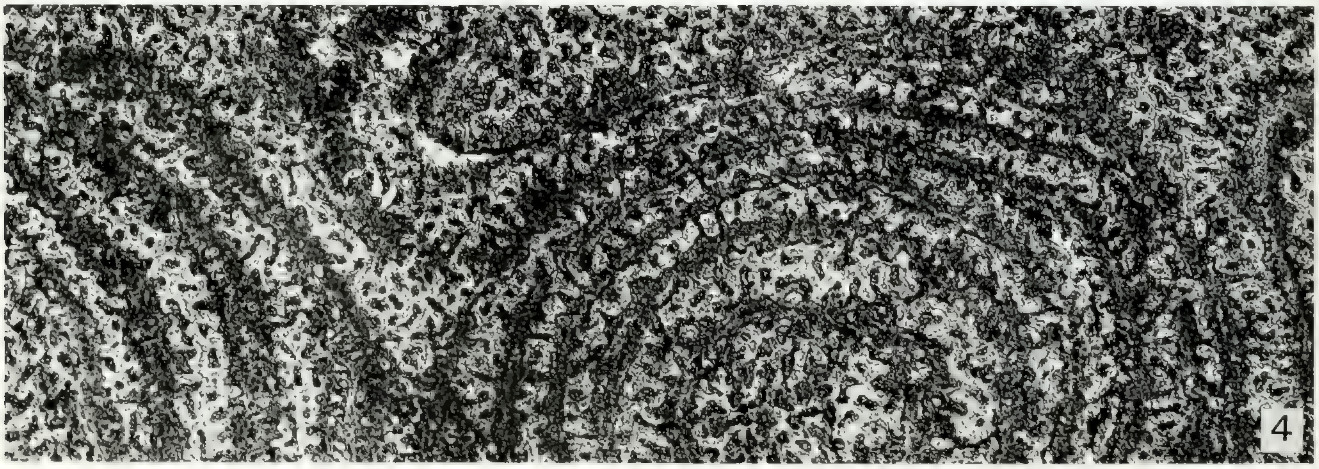
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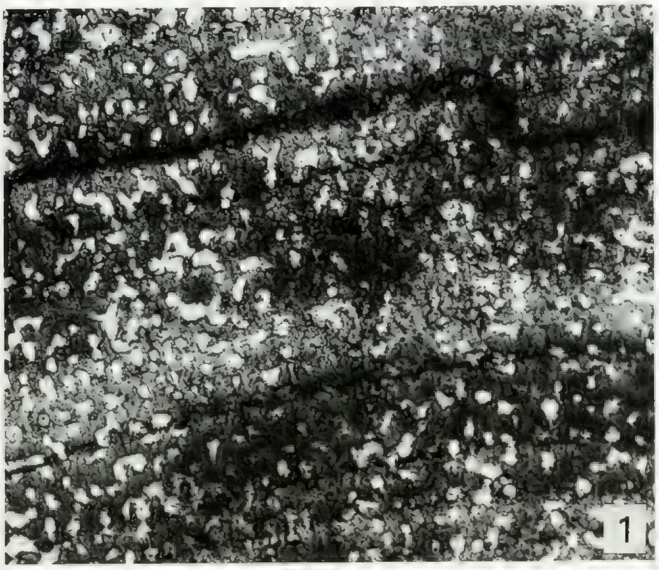
EXPLANATION OF PLATE 12

Figure		Page
1, 2.	*Clathrocoilona vexata*, new species.	28
	1. Paratype GSC 108883. Vertical section; ×10.	
	2. Paratype GSC 108882. Tangential section; ×10.	
3, 4.	*Trupetostroma* sp.	30
	Specimen GSC 108884.	
	3. Vertical section; ×10.	
	4. Tangential section; ×10.	

EXPLANATION OF PLATE 13

Figure		Page
1, 2.	*Stromatopora* cf. *S. hupschii* (Bargatzky, 1881).	31
	1. Vertical section; × 10. Specimen GSC 108887.	
	2. Tangential section; × 10. Specimen GSC 108889.	
3–5.	*Stromatopora hensoni*, new species.	32
	3. Holotype GSC 108890. Vertical section; × 10.	
	4. Holotype GSC 108890. Tangential section; × 10.	
	5. Paratype GSC 108892. Tangential section; × 10.	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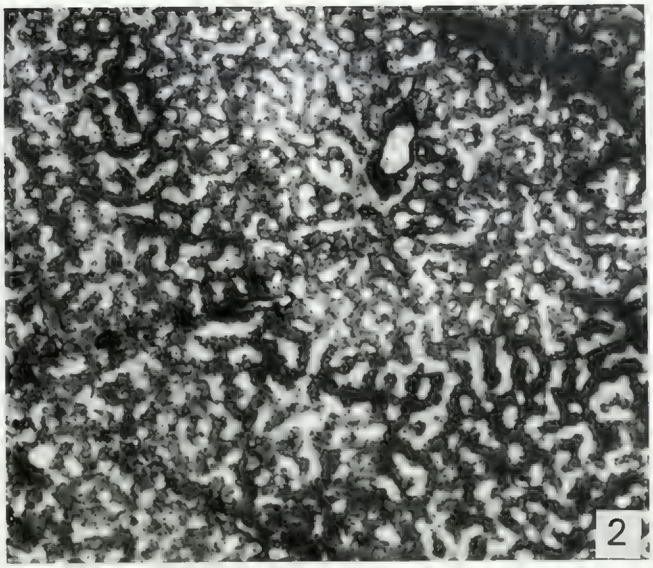
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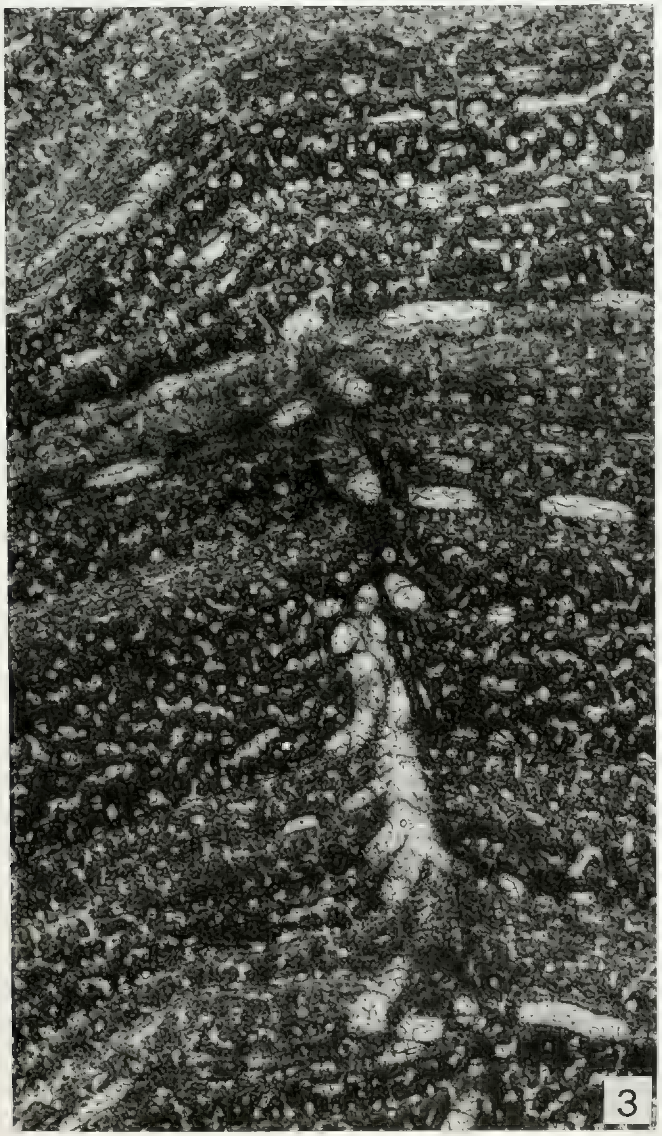
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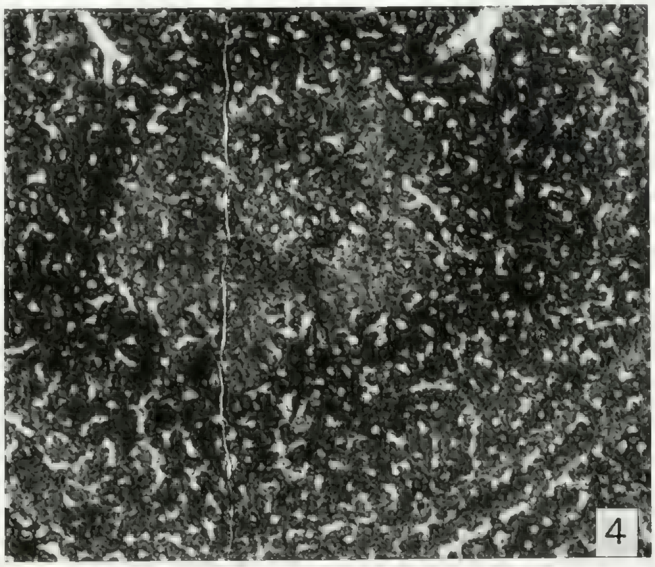
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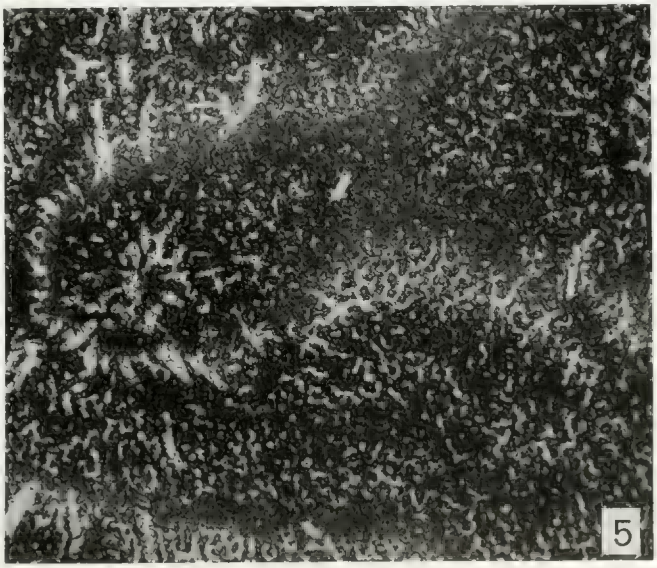
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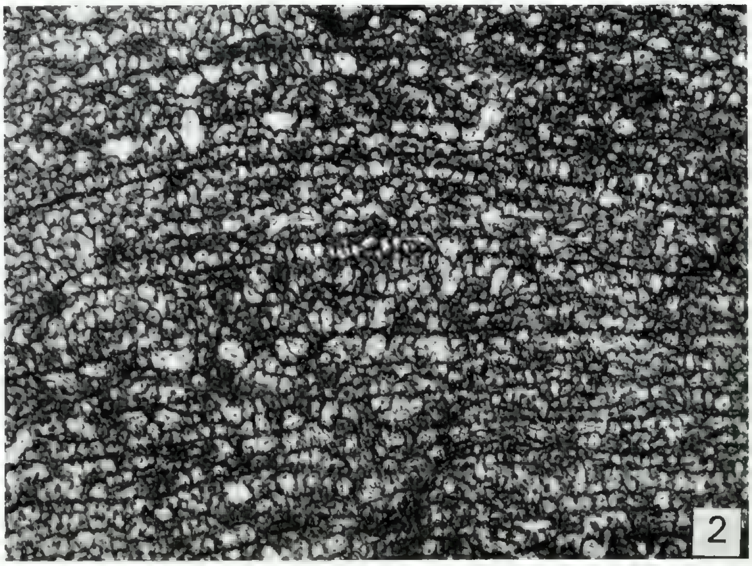
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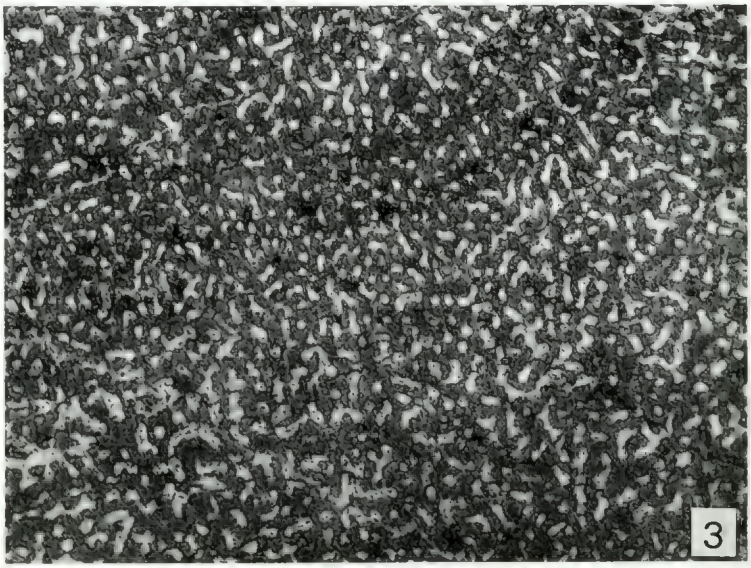
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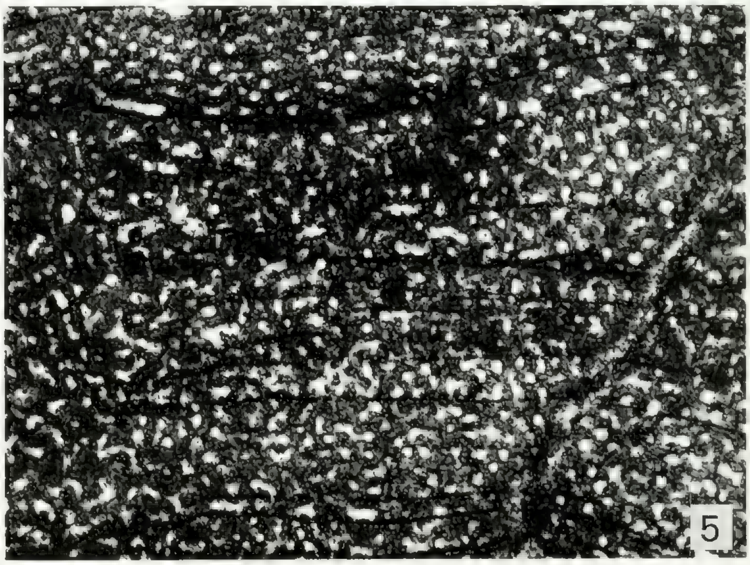
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EXPLANATION OF PLATE 14

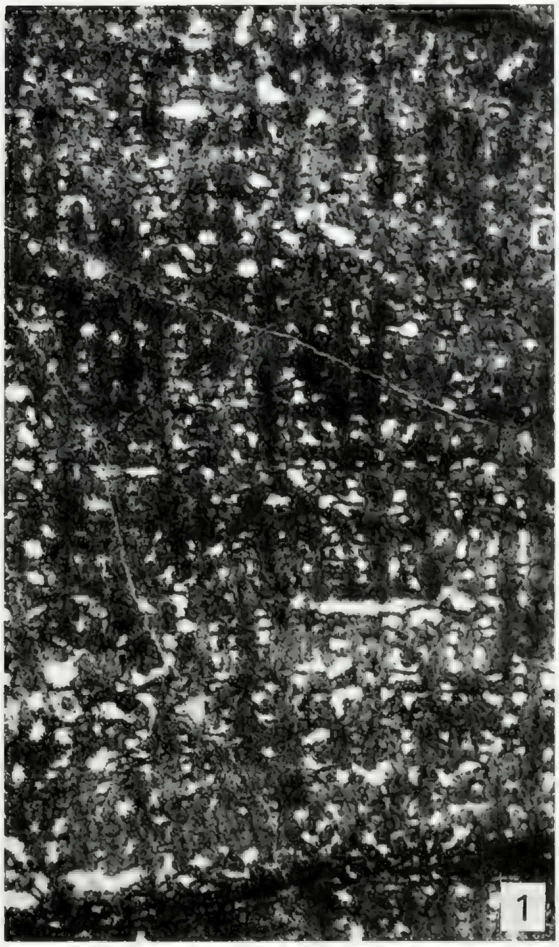
Figure		Page
1, 2.	*Ferestromatopora* cf. *F. krupennikovi* Yavorsky, 1955. Specimen GSC 108893. 1. Tangential section; ×10. 2. Vertical section; ×10.	33
3, 4.	*Glyptostromoides simplex* (Yang and Dong, 1979). 3. Tangential section; ×10. Specimen GSC 108895. 4. Vertical section; ×10. Specimen GSC 108894.	33
5.	*Stromatopora polaris* (Stearn, 1983). Vertical section; ×10. Specimen GSC 108886.	31

EXPLANATION OF PLATE 15

Figure Page

1–3. *Syringostromella zintchenkovi* (Khalfina, 1961). 34
  1. Vertical section; ×10. Specimen GSC 108896.
  2. Tangential section; ×10. Specimen GSC 108897.
  3. Tangential section, detail of microstructure; ×25. Specimen GSC 108897.

4, 5. *Salairella prima* Khromych, 1971. 34
  4. Vertical section; ×10. Specimen GSC 108898.
  5. Vertical section; ×10. Specimen GSC 108899.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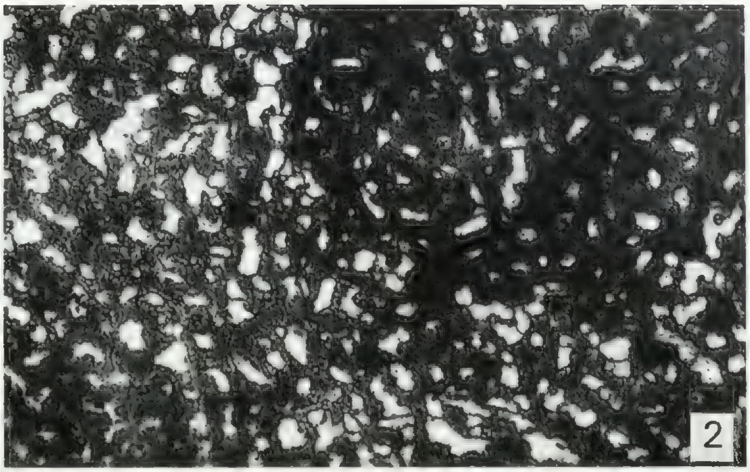
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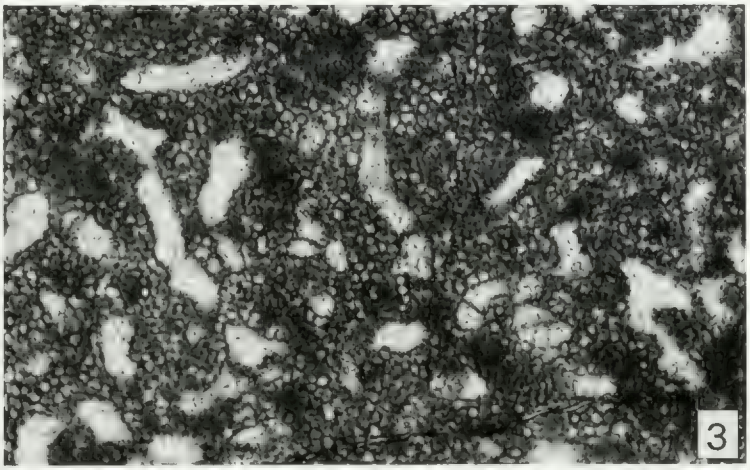
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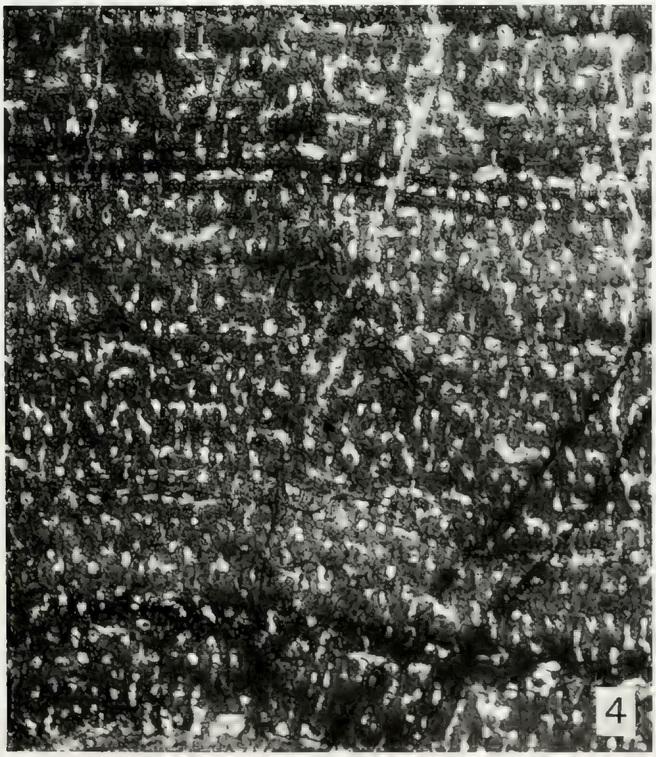
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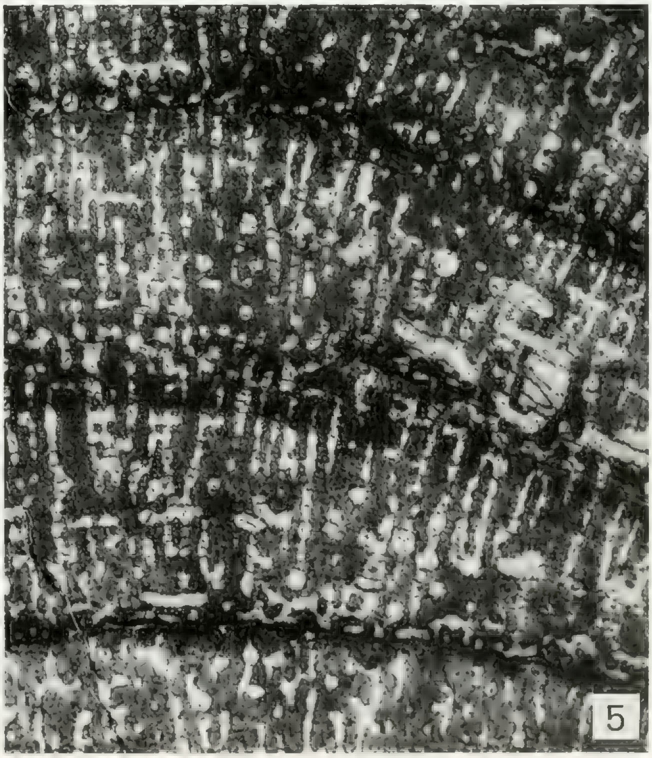
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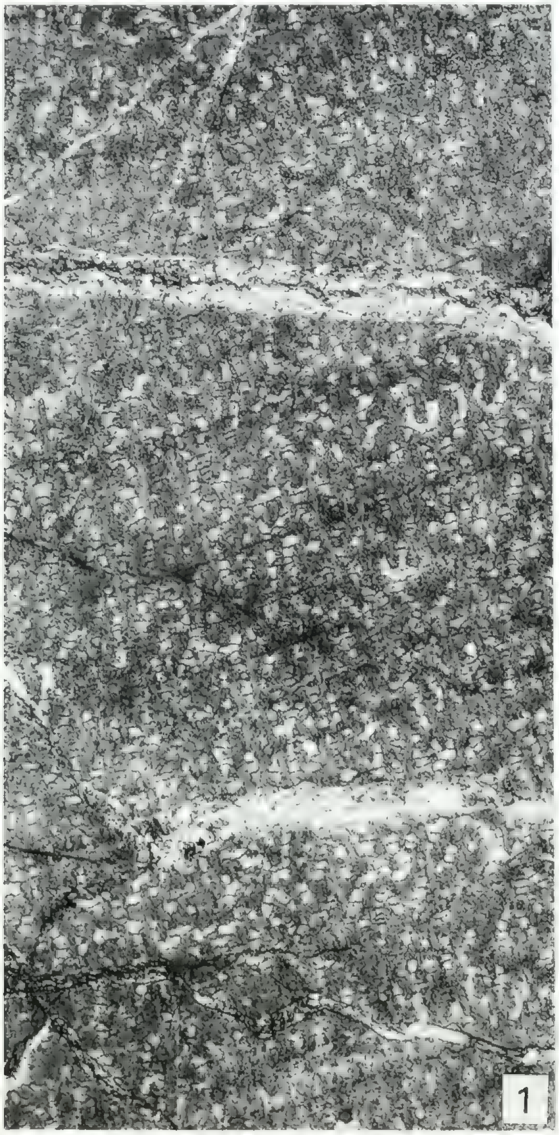
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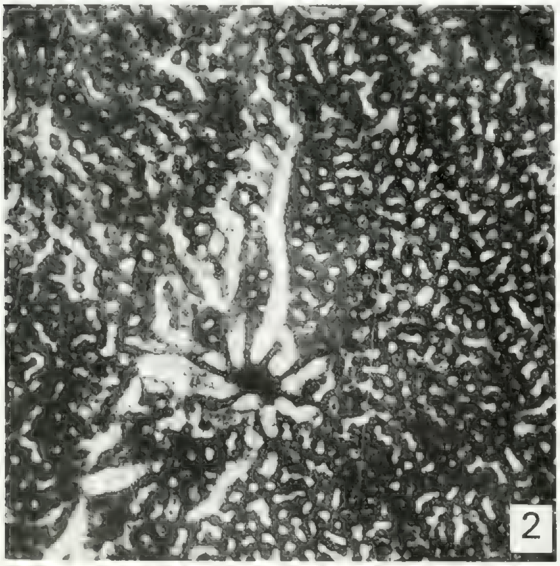
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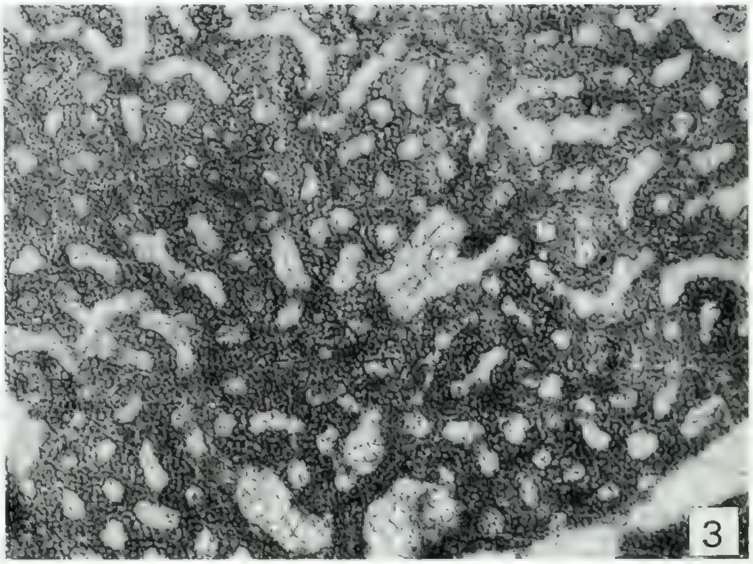
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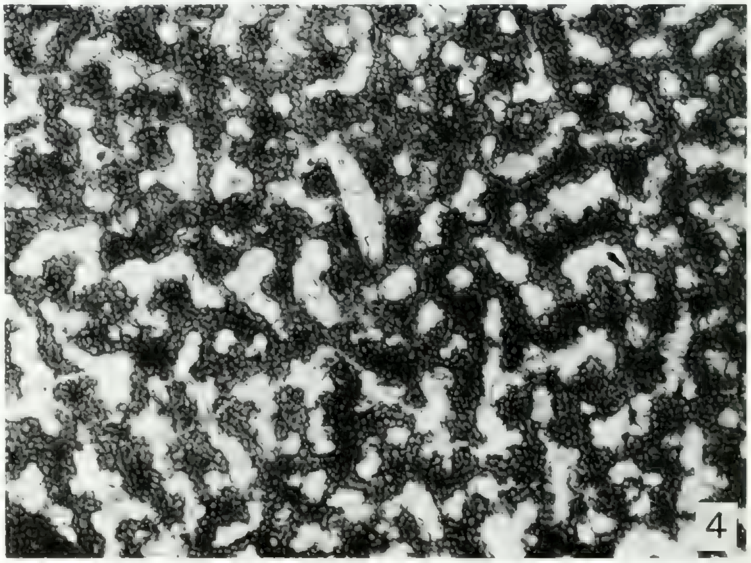
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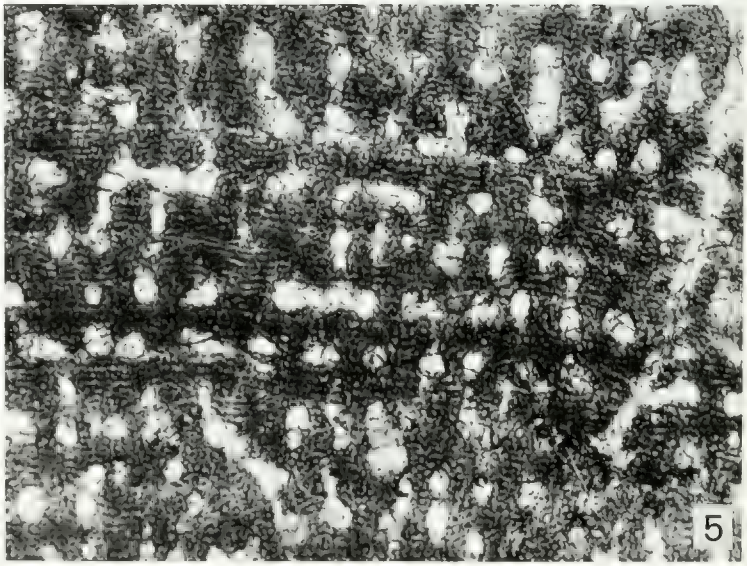
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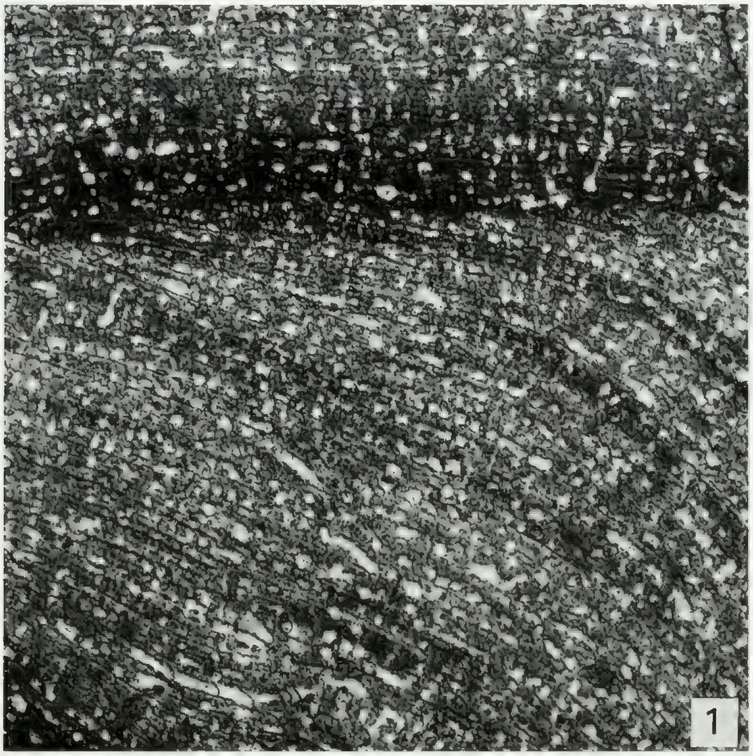
EXPLANATION OF PLATE 16

Figure		Page
1–5.	*Salairella prima* Khromych, 1971.	34

1. Vertical section; ×10. Specimen GSC 108900.
2. Tangential section; ×10. Specimen GSC 108899.
3. Tangential section; ×25. Specimen GSC 108899. Note the smooth termination of cellules bordering skeletal galleries.
4. Tangential section; ×25. Specimen GSC 108901. Note the ragged termination of cellules bordering skeletal galleries.
5. Vertical section; ×25. Specimen GSC 108898. Note the local development of microreticulate microstructure.

EXPLANATION OF PLATE 17

Figure	Page
1–5. *Habrostroma proxilaminatum* (Fagerstrom, 1961).	36
1. Vertical section; ×10. Specimen GSC 108903.	
2. Tangential section; ×10. Specimen GSC 108904.	
3. Vertical section, detail of astrorhiza; ×10. Specimen GSC 108905.	
4. Vertical section, detail of microstructure; ×25. Specimen GSC 108903.	
5. Tangential section, detail of microstructure; ×25. Specimen GSC 108903.	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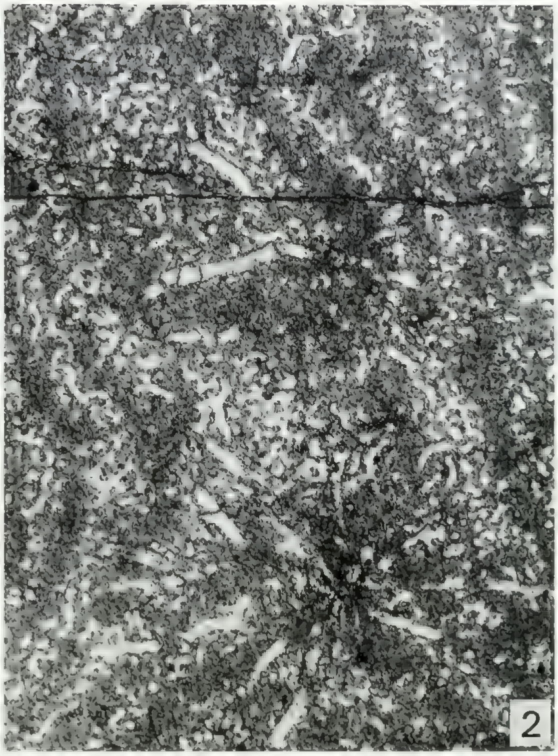
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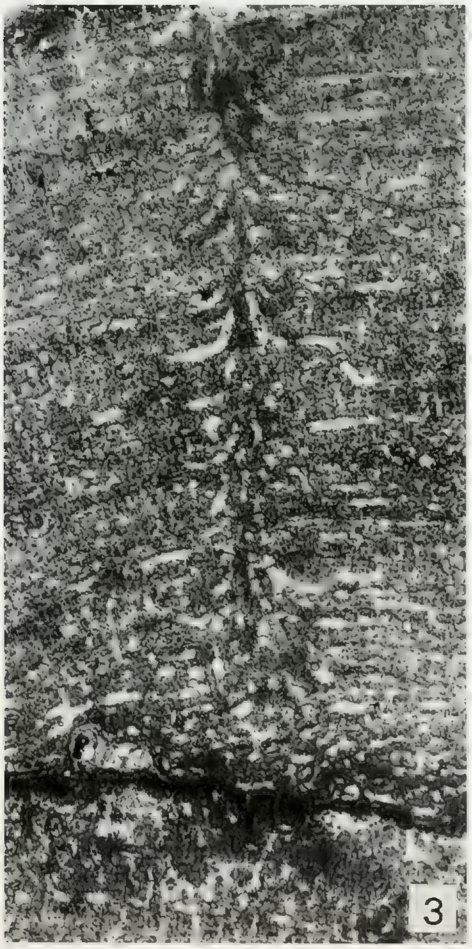
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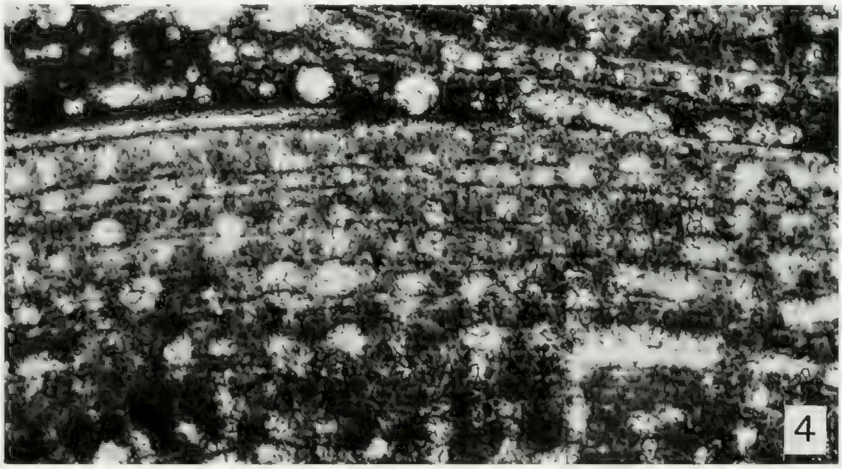
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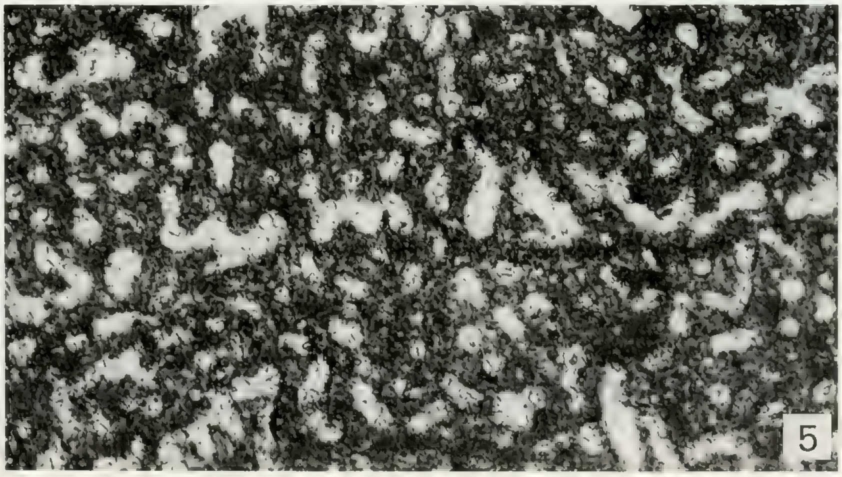
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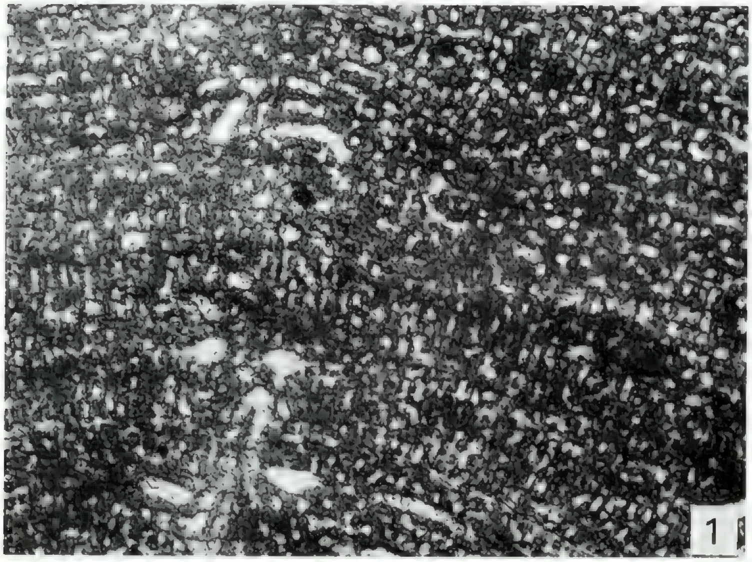
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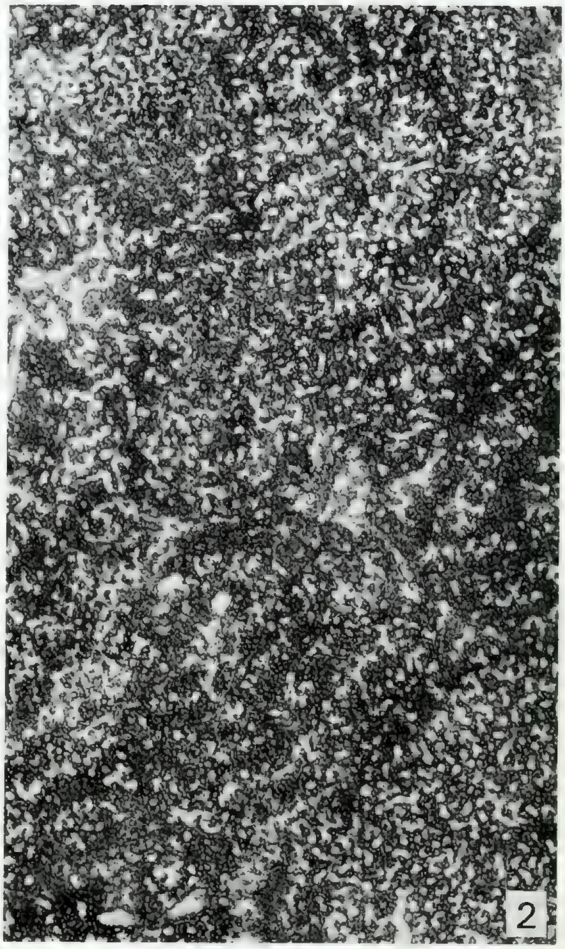
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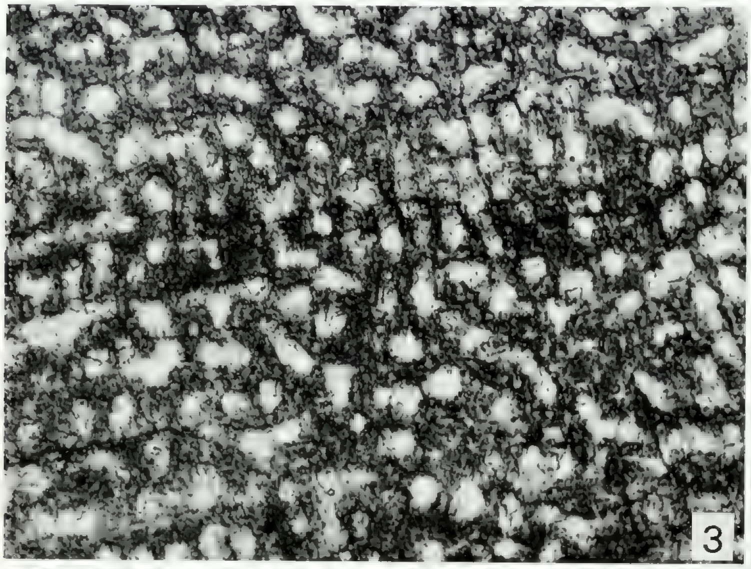
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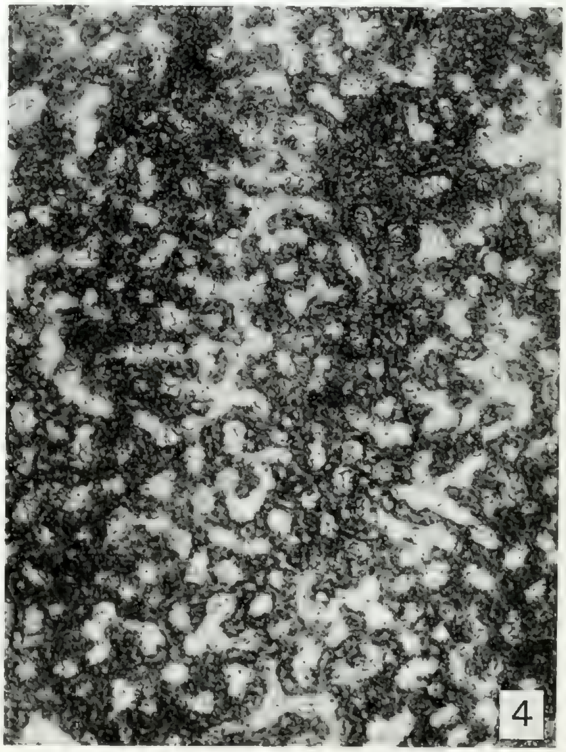
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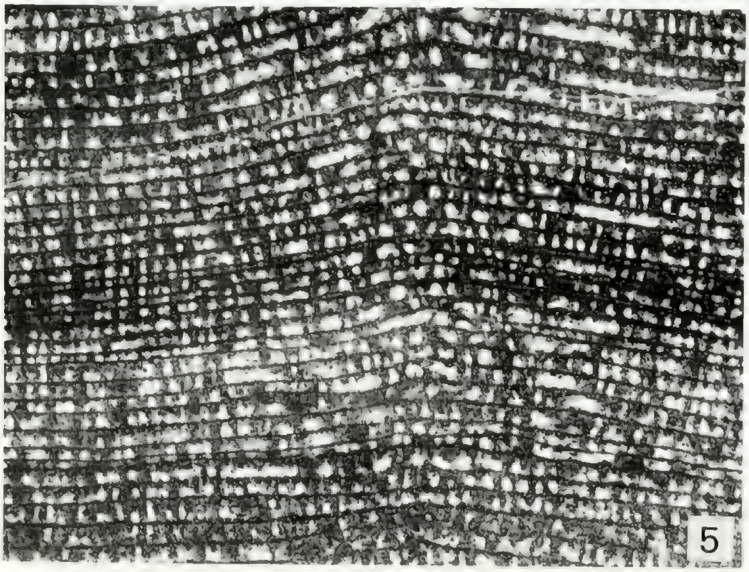
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EXPLANATION OF PLATE 18

Figure	Page
1–4. *Parallelopora campbelli* Galloway and St. Jean, 1957.	37
1. Vertical section; ×10. Specimen GSC 110314.
2. Tangential section; ×10. Specimen GSC 110316.
3. Vertical section, detail of microstructure; ×25. Specimen GSC 110314.
4. Tangential section; detail of microstructure; ×25. Specimen GSC 110316.
5. *Atopostroma distans* (Ripper, 1937).	36
Vertical section; ×10. Specimen GSC 108902.

INDEX

Note: Page numbers in *italics* indicate the location of the taxonomic description. Plates are indicated by the page numbers of their captions in **boldface**. Authors are indexed only where their name appears in the text discussion, not in references. The abstract and bibliography are not indexed. Names appearing on text figures are indexed by page and figure number (eg. 7-F1 = page 7, figure 1).

Actinostroma 14, 15, 16
  clathratum 14, 15
  hebbornense 15
  intertextum 15, 39, 46
  salairicum 15, 16
  sp. A 12-F3, *14,* 15, 39, **46**
  stellulatum var. *distans* 36
  stellulatum 15
Actinostromatida 14–17
Actinostromatidae 14–17
Aculatostroma 16–17
  cf. *A. kaljanum* 11, 12-F3, *16–17,* 19, 39, 40, **47**
  kaljanum 16
akosmoreticulate microstructure 29, 30
Allmon, W. 6
Amphipora sp. 5
Anostylostroma 21, 24
  anfractum 12-F3, *21–22,* 39, **51**
  concept 20
  confluens 22
  hamiltonense 21
  laxum 19, 20
Arctic Archipelago 5
Asia, N. 11
astrorhizae, extraordinary 17
astrorhizal path 14
Atelodictyon 17, 20–21
  cf. *A. solidum* 11, 12-F3, *20–21,* 39, 40, **50**
  cylindricum solidum 11, 20–21
  fallax 20
Atopostroma 19, 35–36
  distans 5, 11, 12-F3, *36,* 42, **63**
  tuntouense 35, 36
Australia 11, 24, 34, 35, 36

Basal phase 17, 18, 19
Bathurst Island 6, 7-F1, 9, 10, 11, 15, 16, 17, 18, 19, 20, 22, 30, 31, 32, 34, 36, 37, 38
Bent Horn oilfield 6
Bioherms 7
Biostratigraphy, stromatoporoid 11–13
Biostrome 9
Bird Fiord 9, 36
Bird Fiord Formation 6, 8-F2, 9, 10, 17, 18, 23, 40, 42
Birkhead, P. K. 30
Bjerstedt, T. W. 38
Blue Fiord 6, 7-F1, 10
Blue Fiord Formation 6, 8-F2, 8, 10, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 30, 31, 32, 33, 34, 35, 36, 39–42
Bogoyavlenskaya, O. V. 17, 18
Bois Blanc Formation 27, 37
Brachiopods 6, 10
Buchans Cave Limestone, Australia 36
Bursykhirmanian horizon 31

Calcite, fascicular-optic 17
Castle bioherm 38
Caunopora hupschii 31
Cellular microstructure 29–30
China 11, 12
Clathrocoilona 27–30
  abeona 27, 28
  cf. *C. saginata* 28
  correlation 13
  crassum 29
  crassitexta 29
  fibrosa 29
  involuta 30
  obliterata 29
  saginata 29
  solida 29
  spissa 29
  subclathrata 30
  vexata 5, 12-F3, *28–30,* 39, 40, **55, 56, 57**
Clathrodictyida 17–26
Clathrodictyidae 17–21
Clathrodictyon 17–18
  cellulosum 26
  ellesmerense 5, 12-F3, *17–18,*39, 40, **48**
  vesiculosum 17
Coenellostroma kaljanum 11, 16
Coenostroma 31
Columbus Limestone 27, 38
Commensal organisms 17, 19, 27
confere (cf.) 13
Conodont biostratigraphy 9–11
Conodont zones 8-F2, 9–11, 12-F3
Corals 6, 10, 11
Cornwallis Island 6, 7-F1, 9, 10

dehiscens zone F2, 9–10, 11
Densastroma 15, 16
Detroit River Group 11, 23, 27, 31, 37, 38
Devon Island 7-F1, 8, 9
Diagenesis 17
Diagenetic alteration 14
Diplostroma 23
Disappointment Bay Formation 6, 8-F2, 8, 9, 10, 18, 31, 34, 35, 37, 39, 41, 42
Dundee Formation 37
Dyke Ackland Bay 9, 16, 32, 37, 38

Eastern Americas Realm 11
Eids Fiord 5, 7-F1, 17, 27, 31, 32, 33, 35, 36
Eids Formation 6, 9, 10, 19, 31, 32, 33, 35, 40, 41, 42
Ellesmere Island 5, 6, 7-F1, 8, 10, 17, 19, 20, 23, 25, 27, 30, 31, 33
Emsian-Eifelian boundary 9, 10, 11

Fagerstrom, J. A. 25, 31, 37
Feldmann, R. M. 38
Ferestromatopora 32–33
  cf. *F. krupennikovi* 12-F3, *33,* 39, **59**
  jacquesensis 31

  krupennikovi 32, 33
  polaris 31
Flügel, E. 15
Formosa Reef Limestone 27, 37

Galloway, J. J. 28, 29, 38
Geological Survey of Canada 14
Gerronostroma 18–19
  cf. *G. immemoratum* 5, 11, 19
  elegans 18
  istekense schirdagica 19
  septentrionalis 5, 12-F3, *18–19,* 26, 39, 40, **48, 49**
  sp. A 18, 19
  uralicumforme 19
Glyptostromoides 33
  simplex 5, 12-F3, 13, *33,* 39, 41, **59**
Goodbody, Q. 10
Goose Fiord 6, 7-F1, 8-F2, 8, 10, 20, 27
gronbergi zone 8-F2, 9–10
Growth, competitive 19
Growth rate 18

Habrostroma 36–37
  densilaminatum 36
  formosense 36
  proxilaminatum 11, 12-F3, *36–37,* 39, 40, **62**
Hermatostromatidae 30–31
Hudson Bay 11

Indiana 22, 38
inversus zone 10, 11

Jeffersonville Limestone 27, 38
Jesse Limestone, Australia 11, 35, 36

Kara-Chumysh R. 15
Karpinskii horizon 16
Kaskaskia transgression 5
Kelleys Island 38
Kerr, J. W. 10
Khalfina, V. K. 34
Khromych, V. G. 16, 21, 34
Klapper, G. 9
Kosareva, E. G. 28, 29
Krekovski horizon 34
Kuznetsk basin 11, 15, 30, 33

Labechia sp. 5
laminae, compound, discussion 23
latilaminae, discussion 17
Lecompte, M. 28
Lessovaya, A. I. 31
Lilydale Limestone, Australia 34
Lochkovian fauna 6
Lowther Island 6, 7-F1, 9, 10, 35, 38
Lucas Formation 38

Malobachatski horizon 34
Mamontovo horizon 30
Marblehead, Ohio 27
McLaren, D. J. 6
measurements, morphologic 14
microstructure, discussion
  akosmoreticulate 29, 30
  cellular 29–30
  classification 35
  Clathrocoilona 28–30
  microtubulate 26
  orthoreticulate 35
  phylogeny 35
  preservation 14
Microtubulate microstructure 26
Mori, Kei 23
Morphologic variability 13
Muskox Fiord 6, 7-F1, 8-F2, 8, 10, 21, 27
Mutualism 19

Natural Sciences and Engineering Research Council 6
Neludimskaya suite 21, 35
Norwegian Bay Member 9
Nuratodictyon 23

Ohio 23, 27, 38
Oliver, W. A. 11
Omulevski Mountains, Siberia 21, 35
Onandaga Limestone 27
Ontario 11, 23, 27

Paleogeography 11–13, 38
Parallelopora 35, 37
  campbelli 11, 12-F3, *37–38,* 39, 42, **63**
Parallelostroma 31
Parasitic organisms 17
partitus zone 10, 15
patulus zone 10–11, 15
Pentamerus pseudobaschkiricus beds 15
Petridiostroma 19–20, 23, 24
  sp. 12-F3, *19–20,* 39, 40, **50**
Petrostroma 19
Phases
  basal 17, 18, 19
  successive 18
Pickett, J. W. 23
Platform, North American 5
Plectostroma 15, 16
  discussion 16
  intertextum 16
  necopinatum 16
  salairicum 11, 12-F3, *15–16,*39, **46**
Polar Continental Shelf Project 6
Polygnathus aff. *P. perbonus* 9
Polygnathus dehiscens 10
Polygnathus gronbergi 9
Polygnathus inversus 9
Polygnathus serotinus 10
Port Colborne, Niagara area 27
Preservation 17
  grades 13–14
Pseudoactinodictyon 22–23
  juxi 22
  conglutinatum 11, 12-F3, *22–23,* 39, 40, **52**

Reef
  fauna 5
  Frasnian complexes 5
  knolls 9
Resolute, NWT 7-F1
Royal Ontario Museum 14
Russia, *see specific districts*

St. Jean, J. 5, 28, 29, 38
Salair, Russia 11, 34
Salairella 34
  multicea 34
  prima 5, 11, 12-F3, *34–35*, 39, 41, 42, **60-61**
Sauerland, Germany 22
Schistodictyon 20, 23–24
  papillatum 24
  posterius 23
Schistodictyon? sp. 12-F3, *23–24*, 39, **52**
Scotese, C. 11
serotinus zone 10, 11
Severo-Vostok, Siberia 11, 35
Siberia, NE 11, 35
Simplexodictyidae, concept 23
Simplexodictyon 23
  grandiosum 23
  simplex 19
Smith, Gary 5, 6, 7, 38
Sör Fiord 5, 6, 7-F1, 10, 27, 31, 32, 34, 35
Species concept 13
Stictostroma 24–26
  anomalum 25
  correlation 13
  eriense 26
  gorriense 11, 12-F3, *24–25*, 26, 39, 40, **53**
  mammillatum 24, 25
  mamilliferum 11, 24, 25
  mccannelli 24, 25
  problematicum 25
Stictostroma? *nunavutense* 12-F3, 19, *25–26*, 39, 40, **54**
Stictostromatidae 24–30
Stock, C. W. 6, 16, 28, 29
stratigraphic ranges 12-F3
Stromatopora 31–32
  cf. *S. hupschii* 5, 12-F3, *31–32*, 34, 39, 41, **58**
  aff. *polaris* 31
  borealis 34
  concentrica 31
  correlation 13
  hensoni 12-F3, 31, *32*, 39, **58**
  hupschii 32
  mammillata 24
  polaris 5, 11, 12-F3, 19, *31*, 32, 39, 40, 41, **59**
  proxilaminata 36
  zintchenkovi 34
Stromatoporella 26–27, 29
  cellulosa 26
  correlation 13
  eriensis 26, 27, type specimen 27
  perannulata 11, 12-F3, *26–27*, 39, 40, **55**
Stromatoporellida 24–31
Stromatoporida 31–35
Stromatoporidae 31–33
Stuart Bay Formation 19, 20, 36
subspecies concept 13
synonymies, general comments 13
Syringodictyon tuberulatum 5
Syringopora 17, 19,
Syringostromatida 35–37
Syringostromatidae 35–37
Syringostroma verrucosum 16
Syringostromella 33–34
  labyrinthea 34
  zintchenkovi 11, 12-F3, *34*, 39, **60**
  zintchenkovi tenuis 34
Syringostromellidae 33–35
Systematic paleontology 13–38

Tababastaakhskaya subsuite 21
Terminology, morphologic 14
Tienodictyidae 21
Tippecanoe Sequence 5
Trilobites 6, 10
Trupetostroma 30–31
  cf. *schelomense* 30
  cf. *T. ideale* 36
  globosum 31
  magnifica 31
  ramulosum 30
  sp. 11, 12-F3, *30*, 39, **57**
  spatiosum 30
  warreni 30
Truro Island 6, 7-F1, 9, 10, 15, 18, 31, 32, 35, 37, 38
Type specimens, repository 14

Ulakhan-Sis Range, Siberia 21
United States, north-central 11
Unnamed Formation 6, 8-F2, 9, 10, 11, 15,
18, 32, 37, 38, 39, 40, 42
Urals Mountains, Russia 11, 16, 17
Uyeno, T. 9, 10
Uzbekistan 19, 23, 31

Variability, morphologic 13
Vendom Fiord 6, 7-F1, 9, 10, 17, 18,
19, 20, 25, 27, 30, 31, 32, 35, 38
Victoria, Australia 11

Webby, B. D. 11, 13, 24, 35

Yavorsky, V. I. 15, 33

Zdimir pseudobaschkiricus beds 15
Zeravshan Range 19
Zhen, Y. Y. 11, 24, 35
Zukalova, V. 30

PREPARATION OF MANUSCRIPTS

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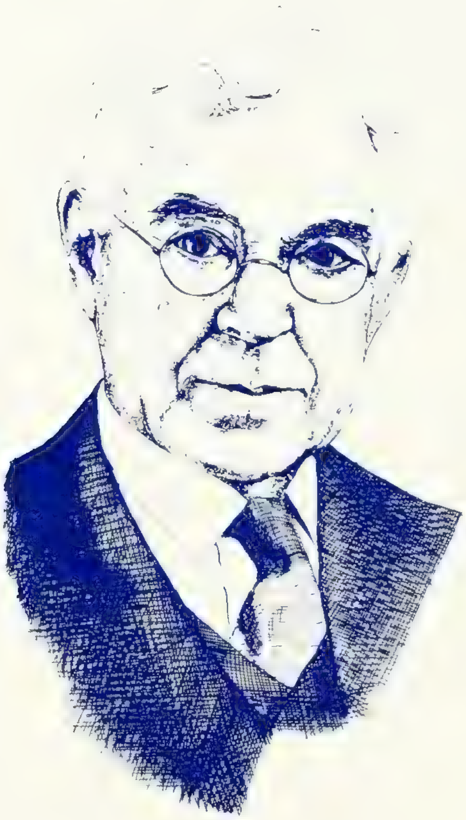

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Gilbert Dennison Harris:

A Life With Fossils

by

William R. Brice

Foreword

by

Frank H. T. Rhodes

Paleontological Research Institution
1259 Trumansburg Road
Ithaca, New York, 14850 U.S.A.

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CONTENTS

Page

DEDICATION 4

FOREWORD by Frank H.T. Rhodes 5

ABSTRACT 8

AUTHOR'S NOTES AND ACKNOWLEDGMENTS 8

CHAPTER 1. "ITEMS HERETOFORE BUT VAGUELY KNOWN" 9

- Early Life and Family 9
- College Days at Cornell 11
- Geological Survey Activity 12
- Washington, D.C. and Separation from his Family 14
- Clara Stoneman and Gilbert Harris 16

CHAPTER 2. RETURN TO WASHINGTON 22

CHAPTER 3. RETURN TO CORNELL 36

- Printer and Publisher 38
- Teacher 42
- Women Students 45
- Field Camp and Boats 46
- Helderberg Field Camp 49

CHAPTER 4. *ECPHORA* 55

CHAPTER 5. THE LOUISIANA SURVEY 63

CHAPTER 6. CONSULTANT 71

CHAPTER 7. CARLOTTA J. MAURY 89

CHAPTER 8. CORNELL COLLEAGUES 106

- Adam C. Gill 106
- Ralph Stockman Tarr 106
- Heinrich Ries 107
- Henry Shaler Williams 108
- O.D. von Engeln 114
- Retirement 115

CHAPTER 9. "SOME ROOMY APARTMENT": POST-RETIREMENT AND THE PALEONTOLOGICAL RESEARCH INSTITUTION 116

CHAPTER 10. FINAL WORDS 130

REFERENCES 131

PLATES 137

INDEX OF PEOPLE 152

DEDICATION

TO THE LOYAL MEMBERS, SUPPORTERS, AND BENEFACTORS
of
THE PALEONTOLOGICAL RESEARCH INSTITUTION
for
KEEPING THE DREAM ALIVE

Leaves may fall and wither and be hidden by a blanket
of snow; yet they have in their infinitesimal way modified the stream of life for all time to come.
Each human life in like small measure deflects the current
of intellect through the ages even after firm granite
has crumbled to dust.
Things unseen alone are immortal.

(G. D. H. '35)[1]

---

[1] Untitled poem written by Gilbert D. Harris in 1935 and found among his papers in the Harris Archives at the Paleontological Research Institution, Ithaca, NY (hereafter abbreviated HA-PRI, Ithaca, NY).

FOREWORD

Frank H. T. Rhodes
President Emeritus
Cornell University
Ithaca, New York 14850

There is a certain fitness in the fact that the man who founded the Paleontological Research Institution – surely one of the most improbable and even quirky of all scientific institutions—and who himself printed all its publications for more than half a century, should be memorialized within the pages of those publications. For it is altogether appropriate that the memory and identity of this man should be preserved within the very publication that he used to preserve, identify, and describe so many long-vanished genera and species. William Brice records in this remarkable volume the life and times of Gilbert Dennison Harris with care and comprehensive thoroughness that do justice to his topic.

Harris was born on a farm near Jamestown, New York, in 1864. After winning a scholarship, he entered Cornell as an undergraduate in 1883 and graduated with a Ph. B. degree in 1886, remaining in Ithaca for a year of further studies. Harris joined the Arkansas Geological Survey in 1888 and, a year later, began work with the U.S. Geological Survey, only to lose that position in 1892 as a result of the depression. He worked briefly with the Texas Geological Survey and was appointed to Cornell in 1894, being offered an instructorship in paleontology at a salary of $1,000 a year with possible subsequent promotion to the rank of Assistant Professor. It says much for Harris's early self-confidence that he bargained Cornell President Jacob Gould Schurman up from $1,000 to $1,400 for an initial starting salary. Schurman himself was no mean bargainer.

Within his eighty-eight years Harris lived a remarkably productive life. In fact, this biography, consummately careful and excruciatingly comprehensive in its detail, gives us an account of not one life but of five.

There is first Harris the pioneer Tertiary paleontologist. Harris devoted his life to a study of the rocks and fossils of the Cenozoic Era, first in Arkansas, Louisiana, and Texas, and later in Europe and various parts of South and Central America and the Caribbean. In association with his students, Harris piled up specimens and was the author of definitive studies of many Tertiary species.

There is also a splendid picture here of a second life: Harris the scientific entrepreneur. Though he was a professor at Cornell, Harris never ceased to be interested in economic geology and throughout virtually the whole of his career served the University on only a half-time basis. Under this arrangement, he was granted leave during the spring term in exchange for teaching field studies during the summer term, together with a normal teaching load during the fall term. During the early part of the year he devoted his time to consulting, either working as a member of the Geological Survey of Louisiana or accepting consulting work with a growing number of oil companies in various parts of the world. This combination of activities proved to be a very beneficial one, bringing as it did hundreds of specimens to Ithaca from every corner of the globe and providing access to geological information that would otherwise have been unobtainable. This proved of significant scientific interest, not only in paleontology, but also, for example, in economic terms, reflected in the fact that Harris was among the first to identify a relationship between salt domes and oil and gas accumulation. This consulting arrangement also raised at an early date a topic that continues to be controversial in the academic world today: conflict of interest. Conflict surfaced in a particularly acute form in this case when Harris and one of his former students were working for competing companies.

The third life in these pages is that of Harris the faculty member, during the formative period of both Cornell University and the Department of Geological Sciences there. It was, I think, Mary McCarthy who once observed that academic politics are so vicious because so little is at stake. One is tempted to remember also Woodrow Wilson's comment on becoming President of the United States when he said that he learned his politics as President of Princeton University and then went to Washington to practice among the amateurs. Harris was not a model professor. He was described as a "wonderfully poor" instructor in lecture classes, who had no set method of instruction, had a poor delivery, was seldom prepared, and was known to arrive at his class with lantern slides still dripping wet from the developing process. Yet he was at his best with small groups of students, especially graduate students, and never more so than in the geology summer field camps that he organized in the

Helderberg School of Field Geology, as it was called in the first decade of the century. The students who were enrolled in these summer programs developed a lasting respect and affection for Harris. During four summers, he undertook extended boat journeys, two of them extending over three thousand miles, to study Tertiary rocks and fossils, in each case in launches that he, himself, had commissioned. The accounts of these early trips – along Cayuga Lake and through the Erie Canal, to the Chesapeake Bay and beyond, are vivid and revealing.

Harris was particularly sympathetic towards the interests of women students in geology and not only enrolled them in field camp before this was generally accepted, but also supervised their graduate studies when few other faculty would do so. His relations with them were not always harmonious, but he was clearly an early advocate of women's interests.

Harris's career at Cornell was marked by repeated controversy and dissension. At one stage there were, in fact, four separate departments of earth science at the University, one under Heinrich Ries in economic geology, one under A.C. Gill in mineralogy and petrography, one under R.S. Tarr in physical geography and dynamic geology, and one under Harris in paleontology. The total complement at the time was four professors, each with his own department, and each tending to communicate with the others only by letter. Except with Gill, Harris's relations with his colleagues were rarely harmonious. Yet his association with Cornell spanned a period of forty years.

It was, among other things, this sense of growing distrust between Harris and his colleagues, as well as arguments with the President of the University over a professional conflict of interest and his subsequent conduct, that was a major factor in the creation of the Paleontological Research Institution. This provides the fourth life: Harris the founder. Harris wanted to be sure that, once he retired from the University, his massive collections of Tertiary fossils would be appropriately preserved and curated. He also had a horror of the hazards of fire in McGraw Hall where they were originally housed and, in spite of repeated requests, the University proved unable to offer alternative fireproof accommodation. It is also clear that Harris was convinced that his own field of paleontology, and particularly his personal contributions to the science, were not adequately appreciated and recognized by his colleagues at Cornell.

For these reasons, he slowly developed the idea of establishing an institution, free-standing and wholly independent of Cornell, which would house his collections and provide a basis for continuing research and study. The germ of this idea had, in fact begun in 1895 when he started his own printing operation because he had had difficulty in finding copies of older paleontological publications and in getting his own work published in a timely manner. And so there was a fifth life: Harris the printer. He founded two journals, *Bulletins of American Paleontology* in 1895, and *Palaeontographica Americana* in 1916. He printed them on his own presses, and they continue to be published today. At first, much of the work that appeared in the journals was his own and that of his students, though in subsequent years the journals came to represent a wider range of authors and topics. It was around this that the Paleontological Research Institution gradually grew, housed first in a small cinderblock building that Harris constructed on the grounds of his home in University Heights, and later moved to the present PRI building on the west shore of Cayuga Lake. The provisional charter of PRI was approved by the New York State Board of Regents in 1933, a year before his retirement, and a permanent charter granted in 1936. While he was well into his eighties, Harris was still operating the presses of the institution he created.

Behind these five interwoven stories there stands the enigmatic and complex character of Harris himself. He was evidently a man of contradictory characteristics, kind and gentle on occasions, yet at other times mean and vindictive. Devoted to his students in general, he could be petty and hard with individuals. It was, in fact, a dispute with one of his most distinguished students, Carlotta Maury, that led to serious charges of a conflict of professional interest and a growing strain between himself and the Cornell administration. Devoted as he was to advanced students, he had little time for the general student body. Of the faculty members in the Geology Department, he was the only one who refused to participate in student advising. He even refused to teach laboratory sections. Yet Harris was loyal and caring toward his advanced students, who occupied responsible geological positions in many parts of the world. He was painstaking in assisting them in the study of material they had collected and the subsequent publication of their work, a wonderful mentor and a lasting friend for many. His later years were marked by loneliness and, perhaps, a growing measure of isolation. His wife, Clara, died two years before his retirement, after a marriage of forty-two years.

Looking back on his life, the remarkable institution that he created, the Paleontological Research Institution, owing its founding partly to pique and partly to fear of fire, is, perhaps, his best memorial. Its collection of type and illustrated specimens now numbers well over 30,000 and it houses more than 1.5 million other fossils and Recent specimens. Its publications continue to be consulted by paleontologists around the world.

William Brice brings enviable qualifications to writing this biography. A Cornell Ph. D. in geology, he is Professor of Geology at the University of Pittsburgh at Johnstown. He has taught summer courses at Cornell for more than twenty years. A historian of geology, he is also in one sense a descendant of Harris, for his interest in geology was stimulated in classes taught by the late Professor Johnnie Wells, who was himself one of Harris's students. Brice has also previously written the definitive history of geology at Cornell. All those interested in the history of paleontology will salute him on this latest publication.

GILBERT DENNISON HARRIS: A LIFE WITH FOSSILS

By

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ABSTRACT

Few people did more to unravel the mysteries of the early Tertiary geology of the United States than Gilbert D. Harris (1864–1952). In 1888, two years after graduating from Cornell University, he began his life-long study of the Tertiary, first as a member of the Arkansas Geological Survey tracing the Cretaceous-Tertiary boundary from Louisiana into Arkansas, and then with the U. S. Geological Survey and the Texas Survey. After travelling to Europe to study the Tertiary epochs there, he returned to Cornell as a faculty member in 1894.

Difficulties in locating copies of Timothy Abbott Conrad's early nineteenth century descriptions of Tertiary shells prompted Harris to start his own printing operation. He later founded two journals, *Bulletins of American Paleontology* (1895) and *Palæontographica Americana* (1916), which he printed on his own presses. Both of these journals continue to be published today by the Paleontological Research Institution, the organization Harris founded in 1932.

Harris believed that students learned best by doing actual geological investigations. From 1899–1909 he was involved with two undertakings that facilitated this belief and engaged students in actual geological research; (1) he was Geologist in Charge of the Louisiana Geological Survey, and (2) he conducted a summer field camp in the Helderberg area of New York. For the latter, he supplied boats for transportation in which the students travelled to the camp and from which they did geological field work along canals, lakes, and rivers. Using his boats, Harris and his students made at least four trips from Ithaca to the Southern Coastal Plain collecting fossils and studying the geology they passed at five miles per hour.

Gilbert Dennison Harris, paleontologist, teacher, and printer, through his students, his journals, his own research, and the Institution that he founded, made a lasting mark on the field of paleontology.

AUTHOR'S NOTES AND ACKNOWLEDGMENTS

My first encounter with G. D. Harris came when I began my graduate studies at Cornell University in 1967. At that time the Department of Geological Sciences was housed in McGraw Hall, where it had been in Harris' time, and there were many photographs of former faculty on the office walls. I distinctly remember seeing a picture of a small, gray-haired man bending over a machine. That photograph turned out to be of Harris at the age of 85 working on his printing press (Plate 14). As I started my 30 year association with the Department of Geological Sciences, I took classes from two of Harris' former students, Drs. Storrs Cole and John Wells, not realizing at the time how much of my life would be entwined with the Cornell department and its faculty. In 1976 I began teaching the summer geology classes at Cornell and the summer of 1995 marked my 20th year at this endeavor. Each time I used a fossil for my classes, I was reminded of Harris via Cole and Wells. In 1981 I was asked to prepare a history of the department for the opening of their new quarters, Snee Hall, in 1984. Once again I came in contact with Harris and his contribution as I traced the department's long and distinguished record (Brice, 1989).

As part of the Paleontological Research Institution (PRI) 61st anniversary celebration and reunion held in August of 1993, while dressed in a costume appropriate for the time of early geologic exploration, I presented a brief description of the life of G. D. Harris and the founding of PRI. The following year, 1994, one year before the 100th anniversary of the *Bulletins of American Paleontology*, I was writing a short paper on Harris' field camp in the Helderbergs (Brice, 1994a, 1995), and the subject of a Harris biography came into a conversation with Dr. Warren Allmon, Director of PRI. Suddenly the short paper grew into what you have before you; a tribute to and celebration of the life and work of Gilbert D. Harris to be published in observance of the 100th year of the journal which he founded in 1895.

No work such as this can be created in isolation, and I wish to thank and acknowledge the assistance and support of several people: Warren Allmon, Director, Paleontological Research Institution, who suggested the original idea and who has served as editor and proofreader; the staff at PRI, who were very helpful in locating various items for me; Gould P. Colman and the staff in the Rare and Manuscripts Department, Kroch Library, Cornell University, who assisted me with archive material; the Department of Geological Sciences at Cornell University for allowing me access to their

historical records and their permission to use some of the material; Nancy Brunberg, Administrative Assistant, Division of Natural Sciences, University of Pittsburgh at Johnstown, for typing a portion of the manuscript, and, lastly, I acknowledge the support of my wife, Heather, for her critical reading of the draft, and for living through yet another manuscript. All of these people served to greatly improve the final product, but I bear sole responsibility for any errors or omissions that still exist.

Ithaca, New York August 1995

CHAPTER 1. "ITEMS HERETOFORE BUT VAGUELY KNOWN"

In 1952 a small, gray haired gentleman died at his home on Kelvin Place in Ithaca, New York, just a short walk from Cornell University where he had spent more than half his life. As he had been a very active man, far more active than many, during the last few months of his life it was heart-wrenching to all who knew and loved him to watch a debilitating illness slowly sap his strength and vitality. But on the 4th of December, two months and two days past his 88th birthday, Gilbert Dennison Harris, who began his life during the American Civil War, breathed his last. He and his wife had only one daughter, but through his teaching he left many "children" who carried on his legacy.

EARLY LIFE AND FAMILY

Gilbert Dennison Harris was born about three miles from Jamestown, New York on October 2, 1864. As he liked to say, he came from "strong English stock" (Anonymous, 1934), for his family came originally from England. The Harris family Bible (Lopus and Ingham, 1977) indicates that an ancestor, Walter Harris, died in England December 6, 1654, followed by Gabriel Harris (no information) and William Harris (died in London). The family appears to have emigrated to the British Colonies in the early 1700s, for one Samuel Harris, born March 5, 1697, died at Fort Edwards, New York in 1758. His son, Job (died 1814), moved to Connecticut where his son John was born in Reston April 22, 1766. As a teenager John served as a private in the Revolutionary Army (Downs and Headley 1921, p. 466–467), and then returned to live in Vermont where Gilbert's grandfather, Jonathan Harris (died Portland, May 13, 1877), was born in Halifax[2]. Jonathan married Lucy Miller and the couple raised their seven children in the Halifax and Bennington area of Vermont. Of the three boys and four girls, Gilbert D. Harris' father, Francis E. Harris, was the third son. The second son in this family, who was killed in the Civil War Battle of the Wilderness, also carried the name Gilbert, a name which Francis bestowed on his second son.

Francis E.[3] Harris was born in Marlboro, Vermont, November 29, 1830. He had little opportunity for formal education, something he regretted all his life, and he made certain that would not happen to his children. Francis Harris' mother died when he was young and his father remarried to one Jane Bruce of Bennington, Vermont; this union produced four step-siblings for Francis. At the age of eleven, Francis was hired out by his father to local farmers. Few in the family took much interest in the young motherless boy, except to get all the work out of him they could. But Francis was bright and resourceful and by the age of 17 he was engaged in his own contracting business and employing men much older than himself.

In 1852 Francis followed his older brothers Oscar and Gilbert and several sisters to Chautauqua County, New York and settled near Jamestown. At first he worked as a carpenter and builder, but after his marriage in Salem, March 29th, 1856, to Lydia Helen Crandall he moved to a farm in the town of Ellicott.[4] Lydia Crandall was born in Kinderhook, New York, February 21, 1832 and was only four years old when her mother and father, Stephen and Christina (Benjamin) Crandall travelled with their nine children from Albany to Buffalo on the Erie Canal, a journey that took two weeks to complete. Eventually the Crandall family settled in the Jamestown area (Downs and Headley, 1921).

Francis and Lydia Harris were the parents of six children, four girls and two boys (Downs and Headley, 1921; Lopus and Ingham, 1977); Cora Ethel (b. Randolph, New York, April 6, 1857; d. Falconer, New York, February 22, 1946), Ida Christiana (b. Randolph, New York, November 18, 1858; d. Jamestown, New York, August 15, 1919), Rollin Arthur (b. Randolph, New York, April 18, 1863; d. Washington, D.C. January 20, 1918), Gilbert Dennison (b. Ellicott, New York, October 2, 1864; d. Ithaca, New York, December 15, 1952), Jennie May (b. Ellicott, New York, May 5, 1870; d. Ellicott, New York, March 17, 1872), and Floy Bell (b. Ellicott, New York, February 11, 1875; d. Falconer, New York, October 13, 1968).[5]

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[2] Jonathan Harris' birth date in the copy of the family Bible is illegible, but appears to be June 4, 1790 or 1796 (Lopus and Ingham, 1977).

[3] The E. appears to be for Eugene because the son of his daughter, Ida Harris Petersen, was named Francis Eugene Petersen (Lopus and Ingham, 1977).

[4] A map of Ellicott in 1881 shows F. E. Harris owning two pieces of land, lot 112a, section 10; and lot 51a, section 10 (Anonymous, 1881). This reference is in the private collection of Mr. Michael Anzalone, Chautauqua, NY, and I am indebted to him for the loan.

Francis and Lydia Harris made certain their children had an opportunity to gain an education, and with the exception of Jennie May (who died in infancy) and Ida, all of them attended college. Three of them, Rollin (Ph.B. '85, Ph.D. '88), Gilbert (Ph.B. '86), and Floy (A.B. '97), graduated from Cornell University, and Cora graduated from Fredonia State Normal School (now SUNY-Fredonia). After graduation Cora taught for several years and produced a volume of children's stories entitled, "Half a Hundred Stories" (Downs and Headley, 1921). Floy attended Cornell from 1894–1898, receiving the A.B. degree in 1897.[6] Downs and Headly (1921) indicate she studied Romance Languages and taught in Upstate New York, New Jersey, and California[7] before returning to spend part of her career as a teacher in New York City. In 1914 she returned to the Jamestown area and spent the rest of her days in the small town of Falconer, not too far from the old family farm. Gilbert's older brother, Rollin Arthur Harris, received his Ph.D. in mathematics from Cornell in 1888[8] and was a Fellow in Mathematics at Clark University in Worcester, Massachusetts until 1890 when he joined the Tidal Division of the United States Coast and Geodetic Survey. His position was "Mathematician" and he was to do mathematical calculations; in other words, he served as a "computer" before such work was taken over by machines. He amassed tidal information from various sources and devised methods of reducing these data into a useful form. His work eventually appeared as the "Manual of Tides" which was published in the Superintendent's Reports through 1907. The entire "Manual" encompasses over 1200 pages and received praise from mathematicians and scientists from all over the world. A similar monograph,"Arctic Tides", followed in 1911. Rollin was active in professional societies and presented papers at various meetings (R. Harris, 1898a, 1898b)[9]. Rollin would frequently join his brother, Gilbert, when he and his students were on one of their boat trips to the Chesapeake Bay region, and also worked with him on part of the Louisiana Geological Survey activities (R. Harris, 1902). Rollin eventually became Chief Mathematician and continued working with the Coast and Geodetic Survey until his untimely death from heart disease in 1918.

Gilbert spent his early childhood on a farm near Jamesville at what was known as "Peck Settlement" (Lopus and Ingham, 1977 p. 92) and he ". . . walked three miles to attend the nearest high school . . ."[10] (Anonymous, 1934) which was then called the Jamesville Union School and Collegiate Institute (Palmer, 1953c). Two older sisters and an older brother preceded him at the high school and as Rollin went on to be a teacher in the local area for a short time after his high school graduation and he then received a scholarship to attend Cornell University, young Gilbert had quite a family legacy to continue. As a young boy, he showed a keen interest in and talent for science and mathematics, and he had quite a talent for drawing; a skill that was to be of great benefit to him later. Based upon what must be his first field notebook, Harris was making systematic recordings of observations and information about animals and birds at the age of 10. Several of the entries noted both the generic and specific names along with the common name:

> "RABBIT (LEPUS CUNICULUS) ITS BODY IS 16 INCHES TAIL 2 IT IS ALSO CALLED CONY RABBITS DO NOT DIG AS LONG HOLES AS THE WOODCHUCK ITS YOUNG ARE BROUGHT FORTH IN JUNE 4 OR 6 IN A LITTER Rabbits are sometimes used for food" (p. 9) [Capital letters as in the original; no punctuation in original.]

> "(PROCYON LOTOR) RACCOON Its body is 22 1/2 inches long tail 8 1/4 These animals frequent brooks which abound in minnows and crabs He is a savage fighter when

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[5] Florence is in parentheses next to Floy in the family Bible and Florence is on the gravestone in Allen Cemetery, Poland, New York. Also, in a letter written in 1953 by Harris' youngest sister to Katherine Palmer, then Director of the Paleontological Research Institution, was signed "Florence B. Harris." In this letter she was thanking Dr. Palmer for sending her brother's memorial. Therefore, she must have used "Florence" in professional and formal settings, but within the family she was "Floy." (Florence B. Harris to Katherine V. W. Palmer, November 2, 1953. HA-PRI, Ithaca, NY).

[6] Listing for Florence Belle Harris of Jamestown in *The Ten-year Book of Cornell University, IV, 1868–1908* (Anonymous, 1908, p. 268), and in Hewett (1905, Vol. IV, P. 274).

[7] From a postcard she sent her brother, Floy Harris was teaching in California in 1913. HA-PRI, Ithaca, NY.

[8] Listing for Rollin Harris; attended 1882–85, 1886–88; Ph.B. 1885, Ph.D. 1888, in *The Ten-year Book of Cornell University, IV, 1868–1908* (Anonymous, 1908. p. 268; also Anonymous, 1915b).

[9] Because there will be many quoted references for Gilbert D. Harris, those will be cited hereafter as just "Harris." For citations for any other Harris, either first names or initials will be added.

[10] According to Palmer (1953c), the distance was four miles each way. In either case, in the winter it must have seemed like far more than this for young Rollin and Gilbert.

> attacted [*sic*] by dogs He inhabits the wooded districts of the U. S. A." (p.21)[11]

Many of the pages are covered with very life-like sketches of the creatures being described; field mice, different kinds of fish, birds, etc. Except for the fish, most of the animals are portrayed in some living activity. In the last section of the notebook are systematic records of each animal he saw and the date on which he saw it. He also recorded the dates on which he saw particular species of migrating birds in the spring as they returned to the area:

	"1878				
Robin	March	1,	1878		
Blue Bird	"	7,	"		
Hawks	"	7,	"		
Flicker	"	15,	"	"	(p. 56)[12]

Even though Harris was growing up among some of the finest Devonian fossil beds in the country, these fossils apparently escaped his notice at the time he was making these early observations, for not one entry mentions seeing a fossil. He must have been too busy discovering the world of the living to cast his attention toward animals no longer with us; that was to come later.

After completing high school, Gilbert followed his brother Rollin's example and won a scholarship to attend Cornell University. First however, also like his brother before him, Gilbert taught for a brief time in a small country school, the Dry Brook District School, near his home; teaching by day and trying to keep warm in an attic room with only a kerosene lamp for heat (Palmer, 1953c). Rollin was still a student at Cornell when Gilbert entered in 1883.

Among Gilbert's classmates in geology at Cornell were Charles David White, who later became Director of the United States Geological Survey (U.S.G.S.), and Robert T. Hill, later of the Texas Geological Survey and U.S.G.S. It has been reported that another member of the Class of '86 was David Starr Jordan, later a famous ichthyologist and the first President of Stanford University[13] (Brice, 1989). But actually Jordan had graduated with his M.S. (he skipped the B.S.) in 1872 and was a classmate of another accomplished geologist, John C. Branner. The confusion of Jordan with Harris' class of 1886 apparently arose because Jordan received an honorary LL.D. that year (Jordan, 1922). So technically he was part of the class of 1886, but not really a classmate of Harris. According to his autobiography (Jordan, 1922) however, Jordan did have an indirect connection to the Geology Department, for he helped dig the foundation of McGraw Hall which was the home of the Geology Department for almost 100 years.

According to Palmer (1953c), Harris came to Cornell undecided on a course of study, except that he knew it would be in science[14]. The purchase of James D. Dana's *Manual of Geology* . . . (Dana, 1880) helped him make up his mind (Palmer, 1953a; and personal communication, July 28, 1982). Little did he realize that in a few short years he would assist Dana in preparing the 4th Edition (1895) of the very book which kindled the flames of geological fire in him.

COLLEGE DAYS AT CORNELL

At the time Harris came to Cornell, the Department of Geology was headed by Samuel Gardner Williams.[15] It was under Professor Williams, who is remembered more as a teacher than as a scholar, that Harris began his geological work. Many years later Harris had the opportunity to examine some of the same areas his old professor had described and remarked on the durability and significance of the earlier work:

> ". . . it may be stated that a similar study was undertaken by Prof. S. G. Williams and his results were published in the *American Journal of Science*, 1886, vol. 31, p. 139–145. Subsequent investigations have shown that this author was scarcely warranted in his general conclusions regarding the age and proper correlation of the great mass of limestone between the gypsum beds and Oriskany in central New York, for he believed them to be locally modified Helderbergian deposits, and hence above the Manlius series. But this much must be said in his behalf, *viz.* that he alone has seemed to grasp the true stratigraphic relations of the various deposits about Union Springs, and he alone has emphasized the importance of the Oriskany Falls section in elucidation of Manlius and Helderbergian stratigraphy." (Harris 1904, p. 55)

Even later, in his Annual Report for 1927–28, Harris had even stronger language concerning S. G. Williams' ability as a geologist:

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[11] Small field notebook with front cover missing. No name visible, but it was found among items known to belong to G. D. Harris and the handwriting looks similar to items written by Harris. Earliest date in the small notebook is May 8, 1875. HA-PRI, Ithaca, NY.

[12] Field notebook of G. D. Harris, 1875–1878. HA-PRI, Ithaca, NY.

[13] Class list of the Class of 1886 compiled for the 35th reunion. HA-PRI, Ithaca, NY.

[14] Statistics for the Class of '86 list Harris as "21 years old, 163 pounds, 5'6 1/2" tall, 7 1/4 hat size, and his future occupation is listed as "undecided."

[15] Refer to Brice (1989) for further details on the Cornell Geology Department.

> "Here it may be remarked that the good sense of Hartt[16] made Brazilian geologic investigations possible and put us in the advanced ranks of geologic departments, then the reign of S. G. Williams put us below zero."[17]

In December of 1885, S. G. Williams left the Geology Department to become the first Professor of Science and the Art of Teaching at Cornell,[18] and Henry Shaler Williams, one of Ithaca's native sons, took control of the Geology Department just as Harris was completing his undergraduate work. Harris received the Bachelor of Philosophy in 1886 and was elected to Phi Beta Kappa (1885) and Sigma Xi (1887)[19] (Downs and Headley, 1921).

This new Williams was a better geologist than his predecessor, and the change in department leadership may have led to Harris' decision to remain at Cornell for another year of study. In this he was, again, following the lead of his brother, Rollin, who was continuing his studies at Cornell as well.

H. S. Williams had graduated from Yale where he studied under James D. Dana, and had been at Cornell since 1879 (Brice, 1989). Working with Williams at that time was Charles S. Prosser (B.S. '83, M.S. '86, Ph.D. '07)[20], who served as Williams' assistant in the Devonian Laboratory at Cornell. Williams directed the laboratory for the U.S.G.S. while he taught half-time. As Ithaca is located in one of the world's greatest exposures of Devonian age rocks, it was fitting that the U.S.G.S. Devonian research effort be situated there. Through very careful and detailed study of these Devonian rocks, Williams was able to show that there were exceptions to a widely held belief of the time that a distinct set of fossils characterizes each and every geological formation. He found, for example, that the fauna of the Hamilton Formation was repeated in the Ithaca Formation, which at that time was an important discovery.

Surrounded as he was by H. S. Williams and his Devonian work at Cornell and the rich Devonian material found in the rocks around Ithaca, it is not surprising that Harris had not yet turned much attention to the Tertiary. Later, after he focused on the Tertiary material, he did not totally turn his back on the Devonian, for he published a wonderful series of little handbooks on the fossils and geology of the Cayuga Lake area (*e.g.*, Harris, 1899a).

In his memorial, Cleland (1918), described H. S. Williams as an "investigator" (a "researcher" in today's language), "rather than a teacher." Williams felt that the key to good paleontological work lay in careful and patient collecting (Cleland, 1918). This was a lesson that all of Williams' students learned well. Those students included H. E. Gregory, Stuart Weller, Charles Prosser, Charles David White, and, of course, Gilbert D. Harris. And it was upon the H. S. Williams model of helping students search for answers by careful analysis of the facts available that Harris built his own teaching techniques. According to one of his students, Harris was at his best when sitting around a table with a small group of students working on a set of fossils (Plates 9, 10).[21] More will be said about his teaching and his students in a later section.

GEOLOGICAL SURVEY ACTIVITY

After the extra year at Cornell, Harris joined the Geological Survey of Arkansas in 1888 (Palmer, 1953a, 1953b, 1953c; Olsson, 1954). The choice of positions may have been influenced by the fact that the head of the Arkansas Survey was another Cornellian, John C. Branner. Branner had been a student of Charles Frederic Hartt in the early days of Cornell and had worked with Hartt on the first Imperial Geological Survey of Brazil (Brice 1989; Figueirôa, 1994). Branner's assistant, Frederick W. Simonds, was another Cornell graduate who had studied with Hartt (Heroy, 1942; Brice, 1989).

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[16] Charles Frederic Hartt (1840–1878), first professor of geology at Cornell, 1868–1875 (Brice, 1989).

[17] Annual Report by G. D. Harris to Heinrich Ries, May 8, 1924, p. 2. Heinrich Ries Papers, 14/1/5/691, Box 2, File 2-4, Rare and Manuscripts Collections, Kroch Library, Cornell University, Ithaca, New York 14853 (hereafter abbreviated as RMC-KL, Cornell).

[18] *Ithaca Daily Journal*, May 21, 1900, p. 3.

[19] "I quite approve of the idea of your getting the **Φ *β* K** and **Σ X** keys." Clara Stoneman to Gilbert Harris, September 20, 1890. These personal letters were discovered at a garage sale near Ithaca, NY in 1984. They were being sold for the old postage stamps on the envelopes, but I recognized the name of the addressee, Gilbert Harris, and purchased them for $5.00. They are now housed in the Harris Archives (HA-PRI, Ithaca, NY). These letters are hereafter referred to as "Private collection, WRB, now at HA-PRI,Ithaca, NY." The awards and dates are also listed in a letter to Cornell President Schurman by Gilbert D. Harris, May 1907, HA-PRI, Ithaca, NY.

[20] Charles Smith Prosser (1860–1916). From 1888 to 1892 he served as assiant paleontologist in the Paleobotany Division of the United States Geological Survey at the time Harris was working there in the late 1880s. Later Prosser was a Professor of Geology at Washburn College in Topeka, Kansas, and spent most of his career at Ohio State University. (Cumings, 1916). There is an interesting twist of fate here, for Prosser, one of his teachers while Harris was a graduate student, later returned to Cornell to do his Ph.D. (1907) under Harris' direction. He apparently returned to Cornell in 1900; "Prof. Prosser, of Columbus, Ohio, takes his Ph.D. in the department this spring." *Annual Report of the Department of Paleontology and Stratigraphic Geology; 1899–1900* by G. D. Harris, p. 5. HA-PRI, Ithaca, NY.

[21] Katherine Palmer, personal communication, July 28, 1982.

When Harris began working in Arkansas, the Geological Survey under the leadership of Branner had only been in operation about a year (Branner and Coville, 1891). According to Olsson (1954), it was on this first trip to Arkansas that Harris received his first good introduction to the Tertiary strata of the southern United States. Unless Harris worked at two different locations during that time, however, he could not have been working on Tertiary rocks on this first trip to Arkansas. He was assigned to work with Frederic Simonds in Washington County, and the geologic map for that county which is part of the published report (Harris, 1891b; Simonds, 1891) has no rocks mapped on it younger than Carboniferous; no Tertiary strata occur in the county. The work with the Tertiary-Cretaceous boundary thus did not come until his second trip to Arkansas in 1892:

> "The first part of September, 1892, was spent in reviewing work done along the Cretaceous-Tertiary boundary." (Harris, 1894b, p. 6).

Part of this initial work appeared in an Arkansas Survey report on the geology of Washington County. Harris prepared chapter 18, the portion for the Fayetteville-Huntsville area (Harris 1891b). It is interesting to note that in Branner's introduction to the publication, he listed a total of four people assisting Simonds with the work in Washington County, Harris and three others, but Harris was the only one to get his name on a chapter heading. That, plus the letter from Simonds quoted below, suggests that the work Harris did was of very high quality.

It seems, however, that Frederic Simonds, his supervisor and co-worker on his Arkansas project, was not totally pleased with the final publication of the work, and did not feel Harris received the recognition he deserved:

> "As you may already possibly know that Washington Co. Report [Simonds, 1891] is now out. It isn't so bad after all, but if I had it to do over again I would do a better job. I hardly think that as much credit is given you as ought to have been given. I gave you more but in 'passing thro' [*sic*] the press' all that was eliminated. I was very particular in the matter myself and had your name on the map-proof which I sent back [from Austin, Texas] to Little Rock. But I did not see the page-proof and did not correct the errors until it was all printed. I speak of this at length for I don't want you to think me greedy."[22]

Although his work with the Arkansas Survey started with great promise, a severe illness brought it to a sudden halt almost before it began. According to Olsson (1954), it took Harris several years to recover fully. No mention is made in his memorials (Palmer, 1953a, 1953b, 1953c; Olsson 1954) as to the nature of the illness, but malaria seems quite likely for it was not uncommon at that time (see a letter from his sister quoted below), and recovery was not an easy process. Apparently another equally unknown incident, aside from the illness, must have happened while Harris was in Arkansas that could have ended his career early, for on a post card from his sister, Floy, in 1913, she wrote:

> "It was Prof. Seth [illegible] of Chicago Univ. who helped save your life in Arkansas I'll wager. How queer the two sisters should meet in S. Calif. to teach in the same H.S."[23]

There is some confusion as to just when Harris joined the United States Geological Survey (U.S.G.S.). Palmer (1953a) indicates it was in 1888, but in other memorials, she (1953b,c) gives the date as 1889, a date supported by Downs and Headley (1921). Olsson (1954), however, states that it was in 1890 that Harris started working with William Healy Dall; and in this Olsson is almost correct. The confusion results because, at first, Harris was with the Paleozoic Division of the Survey, no doubt on the strength of being a student of, and having a recommendation from, H. S. Williams. In fact, it appears he was actually working under H. S. Williams, for in C. D. Walcott's report for the "Paleozoic Division of Invertebrate Paleontology" in the Eighth Annual Report of the Survey, is this small statement in the section describing Williams' activity for the year ending June 30, 1887:

> "Mr. C. S. Prosser assisted in the field work and Mr. S. D. Harris added another station in Chautauqua county, N.Y. to obtain data on the Upper Devonian." (Powell, 1889, p. 174–175).

Mr. "S." D. Harris must be "G." D. Harris, especially given the Chautauqua county reference. Also, the timing fits what has been reported by others mentioned above.

It was after this initial work in the Paleozoic Division of the U. S. G. S. that Harris worked with Dall at the Smithsonian, but both men worked for the U.S.G.S. Dall's report for his Division for the year ending June 30, 1889 in the Tenth Annual U.S.G.S. Report said this:

> ". . . and, subsequently, Mr. Gilbert D. Harris . . . [was] temporarily employed for some months." (Powell, 1890, p. 166).

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[22] Frederic Simonds to Gilbert D. Harris, September 17, 1891. HA-PRI, Ithaca, NY.

[23] Floy Harris to Gilbert D. Harris, September 1, 1913. HA-PRI, Ithaca, NY.

From Dall's statement, it seems that Harris was being engaged by Dall, at least temporarily, as early as 1889.[24] At that time Dall was in the early stages of his work on the Tertiary mollusks of Florida and the southern Coastal Plain, and soon after both men would become involved with a large Tertiary correlation project. It was during the association with Dall that Harris really became immersed in the study of the Tertiary that was to occupy him for the rest of his days.

WASHINGTON, D.C. AND SEPARATION FROM HIS FAMILY

Although this was not the first time Harris had been away from home, those first few months in Washington, D. C. must have been difficult for him. Later Harris would have the companionship of his brother, Rollin, who began working there with the Coast and Geodetic Survey in July 1890.[25] In the meantime, there was a steady stream of letters from his family in the Jamestown area keeping him apprised of family affairs and the deteriorating condition of his father. In addition, sometime in 1889 or 1890, Harris became engaged to Clara Stoneman who was living at Harmony, near Jamestown. So young Gilbert, now age 24, was separated from his fiancé and his family at a time when much was happening. His father's health was failing, his mother was not well either, and they were apparently trying to sell the family farm.[26]

In March of 1890 Harris' sister Floy wrote to him about their father:

> "Pa walked to town and back Friday, and did not seem to notice it. I weigh about a pound more than Ma, but she is getting better. . . . I do not know whether Cora [oldest sister and the first born child] will teach the summer term, if she does I think I shall go and study Grammar, Physiology, Physical Geography, and perhaps Algebra. Then there will be a number of weeks to take music lessons. . . . I do not see when I am going to learn Stenography and Type-writing [*sic*]. I think that if I had a typewriter I could practice considerable [*sic*] on it. The younger I could begin the better, it seems to me, but Pa keeps putting it off to some future time . . . Nellie Drummy and I went to a [movie] matinee a few weeks ago. I never went to one before. . . ."[27]

Whereas his brother, Rollin, who was completing his studies at Clark University, could get home that summer, Gilbert's geological work required him to spend the summer in the field. In May his sister Ida noted this fact and passed along some family news:

> "I think ma's [*sic*] health is improving. She grows fleshy a little and has a good appetite. Sometimes pa [*sic*] feels a little blue because land does not sell higher, though he rather thinks he can sell eight acres of the west end of this farm for a thousand dollars, to a Swede man. . . . Rollin writes he thinks to come home about the tenth of June. I am afraid you will not be at home much this summer if your are going in the field to work."[28]

A few days later, Harris received a note from his oldest sister, Cora:

> "Ma feels so strong lately that she has to go and tear up the earth in certain places around the currant bushes. Ida's being home enables her to do about as she pleases and I guess she enjoys herself very well now. I think pa [*sic*] feels a little disappointed in not selling more of his farm this spring and does not feel as much interested in anything as it is necessary to be for enjoyment. . . . I have not been feeling very well lately I rather believe it is malaria for one thing."[29]

A few weeks later while Harris was doing field work around Yorktown, his father's condition took a turn for the worse. First from sister Ida and then from Cora:

> "I have not very pleasant news to tell, but presume you had rather receive it than no news. Pa has been running down for several weeks, and Saturday night he was take [*sic*] vomiting and has been sick since just as usual. We sent for Dr. Scott this morning but it is now quite late in the afternoon and he has not come yet. . . . Hoping you are enjoying yourself in Yorktown . . ."[30]
>
> "Father is yet sick in bed. He has been up very little for over a week. The doctor thought yesterday that he was a little better. Dr. Scott the one employed now calls it ulceration of the stomach, says he thinks that is what has ailed him for 20 years. He thinks however that it will pass away this time without breaking. I tended him last night. He was in considerable pain. The Dr. thinks the particular

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[24] Harris was definitely working at the Smithsonian Institution by June, 1890, because a letter from his Mother mentions his work there. (Lydia Harris to Gilbert Harris, June 29, 1890. Private collection, WRB, now at HA-PRI, Ithaca, NY.)

[25] ". . . that Rollin will take up his abode in Washington." A reference in a letter from Clara Stoneman to Gilbert Harris, July 6, 1890. Private collection, WRB, now at HA-PRI, Ithaca, NY.

[26] An interesting fact that has emerged from a study of the letters written to Harris while he was in Washington, D. C. is the quality of the mail service in 1890–92. It is not uncommon to see on the envelopes, for example, a postmark for Jamestown with the date March 4 at midnight and another on the back showing a Washington, D. C. postmark for March 5 at 10:30 AM. Apparently one and two day service between Jamestown and Washington, D. C. was common in 1890.

[27] Floy Harris to Gilbert D. Harris, March 2, 1890. Private collection, WRB, now at HA-PRI, Ithaca, NY.

[28] Ida Harris to Gilbert Harris, May 4, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[29] Cora Harris to Gilbert Harris, May 11, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[30] Ida Harris to Gilbert Harris, June 10, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

place of disease is in the pyloric canal a very delicate place."[31]

As if all this was not enough, the family was full of mixed emotions about Rollin, who was completing his work at Clark University, because he had no "position" before him, and he had been married on June 13, 1890. Even that event had not been without its problems:

> "We rather cotted [*sic*] on Rollin's coming home to help care for him [their father], but what do you suppose, I was never more surprised in my life. There was a dreadful rain here Thursday but about one o'clock Rollin came with his feet wet having waded some large mud puddles on his way from town. He could hardly stop for dinner and could not change his socks so pressing was the business in getting to Uncle Rob's to tell Emily [Doty, Rollin's fiancé] that the wedding must be postponed until another day on account of his being delayed on the train. Well he harnessed up Bennie our new colt with some feelings of regret I suppose that the carriage was not repainted [Rollin had sent home several requests to have the carriage painted[32]] and took her [Emily] riding to the Burg for a preacher Elder Stone. On Friday afternoon Mr. Wright came over and invited us all there Friday eve [*sic*]. The knot was to be tied at half-past seven but Rollin didn't start from here until eight so we presume she [Emily] got a little fidgety. He [Rollin] put on one pair of pants and found a hole in them so he had to change and you know it generally takes him quite awhile to get ready. Thats [*sic*] the last we have seen or heard from him. He took the horse and carriage so we suppose they [are] riding around the country somewhere. R. [Rollin] says he intends to live over there and he'll have a nice room. He does not talk as though he had any position and we all think it is strange piece of business. None of us attended the wedding[.] we [*sic*] had a good excuse on account of pa's [*sic*] sickness. I did not want to go. I always trusted that he had sense enough not to marry till he at least had some place in the world and as it appears now I and the rest feel much disappointed. I should not think that she would want to marry under the circumstances."[33]

Gilbert heard this news from his mother as well. Like many mothers, his had a problem understanding that geological field work, especially in a coastal area, was not necessarily a vacation. Note that in these letters, and apparently always, his mother, Lydia Harris, wrote without formal sentences:

> "You have had quite a vacation the change will probably do you good even if your work was as hard as at the [Smithsonian] Institution. I think you are having a nice chance to see the country, and living in an atmosphere of intelligence you must feel that you are improving all the time. It was with a feeling of pride that I read the article you put in the Journal[34] a few weeks ago and how I did wish that Rollin could do something worthy of note. You must know how we all feel about his marrying in his circumstances. I have nothing against Emily only marrying under such circumstances, but we must hope for the best he is willing to work and pa [*sic*] thinks of getting him survaying [*sic*] instruments if he does not find any thing to do. . . . It is about haying time. I don't know how ours will be done here . . . the prospect is not very encouraging to farmers. Butter 12 cents a pound and [selling] slow at that we used to think if we had a package of butter it was the same as cash, but now they hardly want it at any price. I don't see how any one can pay for a farm if they run in debt much now days. . . . When do you think of coming home?"[35]

While all the problems at home were coming to him via the mails, Harris had prepared his first professional publication, a one page paper on the fossil gastropod genus *Terebellum* (Harris, 1890). Although the actual publication came a few months later, the dateline at the close of his paper is April 3, 1890.

By late July, one family concern had resolved itself. Rollin had a new position in Washington, but Francis Harris was not improving and Gilbert was not able to get home:

> "Pa is worse. The Dr. was here last evening and this morning. Pa vommits [*sic*] and is in considerable pain, but he rested some last night. Day before yesterday he walked down to Mrs. Wrample's and back, and he ate some steamed fish, perhaps he over did and made him worse . . . Ida and I milk the cows and do the rest of the chores when Ma does not get ahead of us. I have been wishing we lived in town so that I could go to school this fall without boarding up town at some strangers' house. . . . P.S. July 14, 1890-Pa had a very bad night, but he is more quite [*sic*] this morning. . . . Ma thinks Pa is a little better. The Dr. thinks that he is troubled with the Catarrh of the Stomach now more than the Ulceration of the Stomach."[36]
>
> "Pa is no better yet as far as we can tell and of course we know he must grow poorer and weaker. He has not left the bed-room [*sic*] for a week. He not even sits up to have his bed made. We three [sisters] take turns in lying on the lounge nights and do what little we can. More than half

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[31] Cora Harris to Gilbert Harris, June 15, 1890. private collection, WRB; now at HA-PRI, Ithaca, NY.

[32] Cora Harris to Gilbert Harris, May 11, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[33] Cora Harris to Gilbert Harris, June 15, 1890. private collection, WRB; now at HA-PRI, Ithaca, NY.

[34] The article referred to in the letter appears to be the professional paper he published in *The American Geologist* on the fossil gastropod genus *Terebellum* (Harris, 1890), for nothing written by Harris could be found in the *Jamestown Evening Journal* around this date. He evidently sent a pre-print of his paper to his mother.

[35] Lydia Harris to Gilbert Harris, June 29, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[36] Floy Harris to Gilbert Harris, July 13–14, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

> his nights in the past week have been spent in pain and restlessness. The doctor comes every day but seems to do little good as yet. We can do the work very well, that is I mean the caring for pa [*sic*]. Ma gets quite discouraged and nervous once in awhile [*sic*] but still she has a good appetite. Of course I keep hoping each day may find him a little better. Gene intended to do our haying but we hear he has been unwell with a lame side so we are looking for some-one [*sic*] else, . . . I do not worry about that any. I hope you will make us the visit you intended to this summer. Pa would not expect you to work in haying if you were here. Pa said to'day [*sic*], 'Of course if I grow worse and am liable to die it would best for him to come awhile [*sic*]' Of course we're always glad to see you, but you must time your visit when most convenient to you unless something happens to decide. . . . I think Rollin's getting a position has given pa [*sic*] a great peace of mind."[37]

Harris' Mother wrote to him on July 29th with what appeared to be some good news:

> "I think he [Harris' Father] is improving as fast as could be expected after a fast of two weeks he sits up part of the time and lies on the lounge the remainder of the day it seems good to him to get out of his bedroom again how long it will last we can't tell but hope a long time as I have not the strength to take care of him that I used to have and it makes one feel so bad to see another suffering with no power to help them he is now about the same as when Rollin left . . . I think Rollin could not have found a nicer girl [Emily Doty] any where [*sic*] and hope he will proove [*sic*] worthy of her. . . . It has been a very discouraging season for farmers the present our haying is not half done it rains so much of the time they can't work more than one day in a week some of the time so some of it will be poor quality. . . . Brother William [Harris' Uncle] died quite suddenly they called him to breakfast in the morning he felt as well as usual until he went to get up he felt suffocated and he grew worse until afternoon the same day he died they called it influenza the day before he was in his shop at work I suppose. . . . You did not tell me when you are coming home."[38]

Just 14 days after that letter was written, on August 12, 1890, Francis Harris died.[39]

CLARA STONEMAN AND GILBERT HARRIS

In the midst of the anxiety caused by his father's failing health, Harris had the joy of his engagement to Clara Stoneman. Judging by her surviving letters to him, the pair were deeply in love, and wrote to each other almost every week when they were separated; sometimes more often. In a letter to him on May 10th, 1890, she says:

> "Marian wants to know how I am going to stand it after I get to Washington, D. C. without a letter twice a week. I guess I can manage to stand it some way."[40]

In another letter after he had been home for a short visit, probably for his father's funeral, Clara wrote:

> "When ever I close a letter I always wonder if you understand how much I mean it to mean when I say I am,
> Yours truly, Clara"[41]

There is little record of Clara's early life or of her family. The survey maps of 1881 (Anonymous, 1881. p. 116–117) show that a "B. Stoneman" owned property on Chautauqua Lake, New York (adjacent lots 108a and 55a, section 3, and lot 233a in section 22) near the town of Lakewood, not too far from Jamestown. One "C. Stoneman" (possibly Clara's uncle) owned lot 100a, section 16. Some of these Stoneman properties must have had magnificent pine trees on them, for it is said that Gilbert was attracted to Clara as much by the primeval pines on the family property as by Clara's beauty (Palmer, 1953c). Many years later some of the timber on the old Stoneman property was used in building the Harris home at 126 Kelvin Place in Ithaca, New York. Even though some of Clara's letters came from Harmony, New York and she speaks of their home there, the 1881 map of Harmony does not list any property owned by the Stoneman family. The family either rented a house there or purchased it after 1881.[42]

From information in several letters, Clara Stoneman appears to have had at least one and possibly four sisters. In one letter to Gilbert she said, ". . . if the girls will keep still long enough I will try and write a few words more."[43]; from this We might conclude that Clara was the oldest. There is one envelope, postmarked at Gettysburg, Pennsylvania on June 25th, 1918, addressed to "Miss Bertha Stoneman, Ph.D., in care Prof. Harris, Cornell Heights, Ithaca, N.Y.", but forwarded to "212 W. Falconer St., Falconer, NY." From another letter it appears that Bertha attended

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[37] Floy Harris to Gilbert Harris, July 20, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[38] Lydia Harris to Gilbert Harris, July 29, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[39] Funeral services were held on Wednesday, August 13, 1890, at the Harris home on Buffalo Street. He was buried at the family plot in Allen Cemetery. (Funeral notice, page 4, *Jamestown Evening Journal*, Friday, August 15, 1890.

[40] Clara Stoneman to Gilbert Harris, May 10, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[41] Clara Stoneman to Gilbert Harris, September 27, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[42] The letters from Clara Stoneman begin on May 3rd, 1890 and continue in groups until Jan 1892. I assume the gaps are when they were together either in Washington, D. C. or in Jamestown.

[43] Clara Stoneman to Gilbert Harris, September 27, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

Cornell for some of her college work, for from Bertha, "... [Aunt Kate] wanted to learn the Cornell pronunciation [of Latin] ..."[44] Alumni records show that Bertha Stoneman did, indeed, attend Cornell from 1888–1889 and again from 1891–1896. She completed two degrees, the Bachelor of Philosophy (Ph.B.) in 1894 and the Doctor of Science (D.Sc., not a Ph.D.) in 1896 (Anonymous 1908, p. 507; 1922, p. 312; Hewett, 1905, v. IV, p. 523). Her doctorate was among the earliest earned by a woman at Cornell, for the very first one was awarded in 1895 (Conable, 1977). These same University records indicate that in the early part of this century Bertha Stoneman was a lecturer at Huguenot College in Cape Wellington Province, South Africa[45] about the same time one of Harris' former students, Carlotta Maury, was also a lecturer there; there is no record of any communication between the two, but Bertha Stoneman did stay in South Africa for many years. In 1932 Harris wrote to a former student:

> "We are expecting Mrs [*sic*] H.'s [*sic*] sister from S. Africa in Feb. but fear she will be so wedded to the dark continent that she will be returning after a few months"[46]

In addition to mentioning Bertha in her letters, Clara refers to a Marian, who was probably also a sister: "... but Basie and Marian soon came up [to her room] ..."[47] In one letter she speaks of how cold her feet are as she writes, but she will soon go to bed and "... make Basie get them warm."[48] Thus, Basie must have been a sister or at least a cousin. But Basie may be the familiar name of Bertha and not a separate person. It seems she had no brothers, for in a letter to Gilbert after describing some errands for her father she said:

> "You see I have to be a son as well as a daughter in this family. I generally manage to find something to do in the house but when I can't I can take a horse to be shod ..."[49]

Both families were engaged in farming, but the Stonemans appear to have been more landowners than actually working farmers:

> "As for the thrashers they have not made their appearance yet. They will in due time however."[50]

In several letters she speaks of "hired hands" and "the girl who works for us", so her family must have been reasonably well off financially. After 1881, the family seems to have had homes in Harmony and near Lakewood, both of which are near Jamestown and Chatauqua Lake:

> "... when I went away from home [in Harmony] I had to go to Lakewood.... Some weeks it would be much nicer if I had my mail come to Lakewood ..."[51]

In one letter Clara speaks of "hard times", but how much is real and how much is a young girl's attempt at humor, is difficult to say:

> "Yesterday and to day [*sic*] we entertained the thrashers. We did not have a very hard time of it. They did not get here until 4 o'clock yesterday and were through by ten this morning. We had only 180 bu. of oats,-a very small quantity in comparison with the [illegible] bushels some years. I think we will have to shut up the house this winter and take old Jim[52] and the rest of the horses and go 'cousining'. We have hardly enough potatoes to last until spring. It looks as though we are on the verge of starvation! If the wolf comes to the door we will have shoot him and eat him. But I won't cross that bridge until I come to it."[53]

From what Clara wrote Gilbert, her grandmother Stoneman must have been quite a personality for her time:

> "Aunt R.[ebecca] says that Grandmother Stoneman was the first woman in this county who dared to drive her own horse to J-[amestown] and other places without a man along. In those days it was considered a very disgraceful thing to do so, but my grandmother did not mind what the people thought about her and continued to do her own driving. And now I suppose her spirit has cropped out in me."[54]

As with most families of the time, the Stonemans and the Harrises kept horses both for work and transportation. In family letters, along with the sad news that Gilbert's father was ill and not improving, there was news about a sick horse as well:

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[44] Clara Stoneman to Gilbert Harris, July 20, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[45] This is confirmed by a letter from Harris to C. H. Stoelting, February 23, 1914, in which he requests an item, "... for my sister-in-law Dr. B. Stoneman, Huguenot College ..."

[46] Gilbert D. Harris to Floyd Hodson, "Dear Hodsoni", December 29, 1932. HA-PRI, Ithaca, NY.

[47] Clara Stoneman to Gilbert Harris, September 27, 1890. Private Collection, WRB; now at HA-PRI, Ithaca, NY.

[48] Clara Stoneman to Gilbert Harris, May 17, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[49] Clara Stoneman to Gilbert Harris, September 24, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[50] Clara Stoneman to Gilbert Harris, September 27, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[51] Clara Stoneman to Gilbert Harris, October 12, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[52] Given the nature of the sentence the "Jim" must be a horse, but according to another letter she wrote to Gilbert Harris on November 8, 1890, there was a hired hand on the Stoneman farm named Jim as well.

[53] Clara Stoneman to Gilbert Harris, October 2, 1890, Private collection, WRB; now at HA-PRI, Ithaca, NY.

[54] Clara Stoneman to Gilbert Harris, October 19, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

> ". . . we have been quite excited over our sick colt for a week past we had to dose him with powders and drops the same as a person every hour the horse Dr. came five times to see him he is improving very fast . . ."[55]

> "Our colt seems to fed [*sic*] pretty well but no one has used him since he was sick to see if he stands it all right. He and Belle run out to pasture together."[56]

> "Yesterday I got Jim shod and the buggy fixed"[57]

Mixed with the less than good news about his father and family problems, Harris was receiving letters like this from Clara who was then in Harmony, New York:

> "Marian and I have been to Ashville this evening and got a whole armful [*sic*] of mail, but nothing among it all satisfied me as your letter did which I did not see at first and and [*sic*] I was worried for fear it had not come. . . ."[58]

His fiancé was also mindful to keep him abreast of any events of geological interest in the Jamestown area, even while he was in Yorktown, Virginia living in a fisherman's shack:

> "I believe there is a gas well being drilled . . . if that is of interest to you. . . . It is called the Chase Well."[59]

And she related events not so geologic in character while expressing her concern for him:

> "I was glad to hear of your safe arrival at your destination [Yorktown, Virginia], and I hope that you will enjoy yourself and *be sure* and do not get sick. . . . I had a rather swell ride the other day. I came home from Jamestown on the [street] cars and started to walk up the R. R. track. I met the men who work on the track and the boss told me that I might ride up to our crossing on the hand car. So I got on and I came up in a hurry. It was much better than walking up in the sun." [Emphasis in the original.][60]

Harris was in Yorktown in April and June, 1890 on assignment for the U.S.G.S. to study the well known Miocene beds of the Yorktown area. By this time, Harris was well and truly into Tertiary work, for Dall's report to the Director of the U.S.G.S. for June, 1890, lists Harris with a promotion, "Gilbert D. Harris, assistant paleontologist", and Dall describes Harris' trip to Virginia:

> "Mr. Harris has assisted in the routine work and has been also able to give a few weeks to field work on the Yorktown, Virginia, peninsula, all that our scanty allotment would permit of undertaking. . . . In the month of June Mr. G. D. Harris was sent by me to the vicinity of Yorktown, Virginia, to make some collections from the Miocene of that region and verify some stratigraphic details which were in doubt. He was absent about two weeks with satisfactory results." (Powell, 1891a, p. 109, 111).

Based on his Yorktown work, Harris prepared a manuscript, complete with outcrop sketches and fossil descriptions. This manuscript was not published in its entirety, however, until 1993 when the Paleontological Research Institution published a facsimile of Harris' handwritten manuscript with annotations by Lauck W. Ward (Ward, 1993). The failure to publish this work is particularly puzzling in light of what Dall had to say about Harris' Yorktown study in the same report quoted above:

> "This work has been carried out in an exceptionally satisfactory manner, geologically speaking and will be incorporated in the correlation essay." (Powell, 1891a, p. 109).

Unless there were two different studies made, Dall must have been referring to Harris' Yorktown work.

Druid Wilson, a former student of Harris' at Cornell in the early 1930s and a paleontologist with the U. S. Geological Survey for many years, kept the manuscript in a file cabinet in his office. He thought it was part of material he inherited from Julia Gardner, distinguished Cenozoic paleontologist and his predecessor in that office. According to Wilson[61], even though the manuscript had no name on it, everyone who saw it recognized its value and most recognized Harris' handwriting as well. In his mind, these two things preserved it over the years.

As to why it was never published, Wilson felt that based upon the writing style and the fact that there was no name on it, there was never any intention to publish it, at least not as it was. Wilson thought that the manuscript represented notes that Harris put together for Dall as they were preparing their large Neocene volume. Information from this 1890 manuscript was, indeed, used by Dall and Harris in their *U. S. Geological Survey Bulletin* 84 (1892, p. 59–62). About 20 years after this, Clarke and Miller (1912) also used some of the information.

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[55] Lydia Harris to Gilbert Harris, June 29, 1890. private collection, WRB; now at HA-PRI, Ithaca, NY.

[56] Floy Harris to Gilbert Harris, July 20, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[57] Clara Stoneman to Gilbert Harris, September 24, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[58] Clara Stoneman to Gilbert Harris, May 3, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[59] Clara Stoneman to Gilbert Harris, May 17, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[60] Clara Stoneman to Gilbert Harris, June 7, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[61] Personal communication, July 12, 1995, and comments in a letter from Druid Wilson to John Pojeta, May 4, 1982, a copy of which is in the HA-PRI, Ithaca, NY.

> "The above section was prepared by G. D. Harris, who made a careful study of the Yorktown cliffs for Dr. Dall." (Clark and Miller, 1912, p. 162).

In 1980, Ward and Blackwelder mentioned the Yorktown work of Harris again:

> "The first comprehensive treatment of the strata on the York river in the vicinity of Yorktown, Va. was done by Harris (1890 unpub. manuscript), Dall and Harris (1892) described some of the beds in this area but made no attempt to name them." (Ward and Blackwelder, 1980, p. 28).

The eventual publication of Harris' original report, as annotated by Lauck Ward (1993), is not only historically valuable for the geological descriptions it contains (many localities are no longer available for study); the manuscript is also a good example of Harris' beautiful penmanship and skill at illustration. Even though originally Wilson did not feel the manuscript was intended for publication in its original state, the annotations added by Ward have made it, in Wilson's opinion, a very valuable addition to paleontological literature.[62] That opinion is shared by a reviewer of the volume who wrote:

> "Knowledge of the stratigraphic localities along the York River would be lost but for the meticulous descriptions of them by Harris as reproduced by Ward. . . .
>
> "This book is recommended to serious students of stratigraphic paleontology of the eastern United States." (Moore, E., 1995, p. 113).

High praise, indeed, for a manuscript that was written over 100 years earlier.

From the comments in Clara's letters, Harris' quarters in a fisherman's shack at Yorktown must not have been very comfortable for him. She continued sending the geological news:

> "I am glad to know that you are through with your present work in Yorktown and are going to get back into more comfortable quarters [in Washington, D. C.]. How dissagreeable [*sic*] it must be wherever you go to be troubled with bed-bugs. . . . I was reading this morning that the N. Y. State Geologist had been travelling through Missouri and some of the Southern States inspecting fossils. I tried to find out something about the Harmony oil well but did not make out much. They are about ready to commence drilling and I believe the name of the man who has charge of it is Charles Dean. . . ."[63]

In one letter, written on July 20th, she enclosed an undated newspaper clipping about "Searching for oil" near Panama, New York and stated that they were:

> ". . . down 1400 feet, and the drill is progressing at the rate of 100 feet daily. It is hoped to reach 2000 feet by Saturday night. As yet there are no indications of oil or gas."[64]

Then four days later on July 24th, there was a small note enclosed with her letter with information from the morning newspaper:

> "1st. The J. E. Dean well near Panama [NY] has proved a dry hole at a depth of 1500 ft. No signs of oil or gas.
> 2nd. The well that has been drilled by Dean & Co. near Panama has been plugged up and a man left to watch it[65]. It is believed by some that gas has been found."[66]

Clara's letters reflect how much in love they were and how difficult it was for them to be separated:

> "How I wish you could only be here even for a little while. I would like to feel your dear arms around me and to put my arms around your neck and be ever close, close to my darling and receive one of your precious kisses and then maybe I would let you go but it would be so hard. [signed] Your Clara."[67]
>
> "I was sadly dissappointed [*sic*] last night not to receive your regular letter which usually reaches me on Saturday morning. What was the reason, dear one? I trust that it was not because you are sick that you were unable to write, yet I fear that that was the reason. It worries me so to be so in doubt. I went to sleep last night with thoughts of my Gilbert in mind and awoke this morning with a sense of some trouble over me. But I have tried to think that everything was all right and to make myself believe that you had some good reason for not writing. How I wish I was with you then I would know. I received your letter of Monday in good time and have had to make that do for two."[68]

The closer the time came to their wedding, the harder it was:

> "I don't know that I want the time to go by any faster but I do wish this waiting was through and the time had at

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[62] Personal communication, July 12, 1995.

[63] Clara Stoneman to Gilbert Harris, June 15, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[64] Clipping attached to a letter from Clara Stoneman to Gilbert D. Harris, July 20, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[65] A small article about plugging a gas well near Harmony, NY appeared on page 1, *Jamestown Evening Journal*, July 21, 1890.

[66] Note enclosed with a letter from Clara Stoneman to Gilbert Harris, July 24, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[67] Clara Stoneman to Gilbert Harris, June 18, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[68] Clara Stoneman to Gilbert Harris, July 20, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

> last come where we could be together. Oh! I do wish it so much."[69]
>
> "I can hardly realize that in so short a time there will be no more of this uncertain communication. Then how happy, happy we'll be."[70]

In her letters were repeated references to her fear of illness. Any time there was a break in his schedule of letters, Clara feared for his health:

> "When she [Marian] came back [from the post office] she said she had bad news to tell me, that there was no letter from Wash. with your handwriting upon it. That worried me somewhat for I feared that either there was no letter from you or that you were sick and someone else had written for you but as she looked rather pleasant I concluded that nothing special had happened." [Harris had typed the address. At that time Clara had never seen a typewriter.][71]

Her concern was not misplaced, for after returning to Washington following his father's funeral, Harris must have injured his back:

> "I am sorry for your lame back. It is not pleasant I am well aware. I hope it is well by this time. I am afraid you are trying to do to [*sic*] much muscle work. You seem to be so busy all the time. I am afraid it is not well for you."[72]

> "I hope your lame back has 'let up' before this, but if it has not I wish you would see if you could do something to make it do so. 'An ounce of prevention is worth a pound of cure' you know. Possibly though, you will not thank me to quote such a worn out proverb as that for your benefit."[73]

But all was well eventually:

> "I am glad to know that your back does not trouble you now and hope it will not again."[74]

Living as most of us do in modern urban settings we forget what life was like in a farm community before the advent of antibiotics and the modern medical care that we enjoy today. Illnesses and injuries we do not even consider important were often life-threatening in 1890. In several family letters there are references to the deaths of friends and relatives alike. This must have had an effect on Harris, especially news about the death of children as he was about to be married:

> "Dr. Wellman has lately lost his little boy about two years old"[75]
>
> "One of the Forbes twins died Saturday night. It [*sic*] had inflammation of the brain. They thought the cause of its [*sic*] death was falling off the veranda and hitting its [*sic*] head on a stone."[76]
>
> "Awhile ago I read that Blance Ames Weate had a daughter born and this week I read again that her boy was dead."[77]

There was communication between the two families and Clara was aware of Francis Harris' condition, for she wrote to Harris:

> "Floy's [Gilbert's youngest sister] letter was very nice and interesting. I was much amused at the way she described some of the happenings. . . . It is too bad that your father has to be sick so much and it seems strange that he can stand so many sick spells. I wish I could go down to see your folks but I cant [*sic*] see the way to do so soon."[78]
>
> "I am sorry to know that the state of affairs at your home is not more cheerful and I would think your father would be about discouraged. It is so bad for your mother to have so much care upon her now. It is really too bad neither of you two boys can be at home just when your folks need you the most. But I suppose that is the way of the world."[79]

But all this constant correspondence was not without its difficulties for young Clara, especially when she considered that Gilbert was all alone in that big city [his brother did not arrive until late July 1890], and that he might not have his "position" renewed:

> "The mosquitos are so thick I am afraid they will eat me up so if this letter should stop suddenly in the middle of a sentence you may know what has happened. I have the ammonia bottle standing near. . . . I was quite surprised to learn that Rollin will take up his abode in Washington. That will be very nice, especially if you can live with him, although I should think you would dislike to leave Miss Brown. But then I suppose if that 'old maid' (I would be so polite as to say 'elderly maiden') entangles you by her wiles you would then have to leave him [Rollin] anyway.

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[69] Clara Stoneman to Gilbert Harris, October 23, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[70] Clara Stoneman to Gilbert Harris, November 8, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[71] Clara Stoneman to Gilbert Harris, October 2, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[72] Clara Stoneman to Gilbert Harris, October 2, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[73] Clara Stoneman to Gilbert Harris, October 5, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[74] Clara Stoneman to Gilbert Harris, October 12, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[75] Ida Harris to Gilbert Harris, May 4, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[76] Ida Harris to Gilbert Harris, June 10, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[77] Clara Stoneman to Gilbert Harris, October 30, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[78] Clara Stoneman to Gilbert Harris, June 28, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[79] Clara Stoneman to Gilbert Harris, July 28, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

> The 'E.M.' better 'watch out' or she may hear something heavy drop some day and feel it too[.] . . . You did not write whether you had received your appointment this year or not so I concluded you did not know about it when you wrote last. I suppose that will come around all right in time."[80]

The visit Gilbert's mother wanted and Clara desired came as a result of his father's death in August of 1890. His stay at home was a short one, however, for Clara's letters resume on September 13, 1890. Apparently he and Clara had talked during their time together about their future and his aspirations, and about their beliefs. Gilbert, also, must have spent some time with his prospective father-in-law, for Clara wrote:

> "I would be very glad to help you with your writing when I get to Washington, that is, if you think I can write good enough but you know that socks are prone to holiness and I am afraid that yours will be in that condition by the time I get there. Maybe if I get up extra early in the morning I can attend to both. . . . I presume that you think my father is not very talkitive [*sic*], well he is not I must say, but still if you give him time to collect his ideas he would make quite a conversationalist . . . I tell you all this to show you that he is not dumb as you may hear sometimes. . . . If staying away from church for a few weeks throws you so far off the track what do you suppose I must be who has not been to church from nearly a year"[81]

This reference to church gives a glimpse into the spiritual side of Harris' life, of which, unfortunately, we otherwise know very little. There must have been at least some family tradition of belief and church going, for the family kept a large Bible in which important events were recorded (Lopus and Ingham, 1977), and family letters contain various religious references:

> "I am leading about as simple a life as the shepherds did at Christ's birth. This is some comfort to think that the angel appeared to them first."[82]
>
> "Ida and I went to church[83] to'day [*sic*], the first time for months."[84]

In their description of Harris, Downs and Headley (1921, p. 467) state that, ". . . in his religious views [Harris was a] liberal.", but there is no indication what denomination or the source of the information[85]. The funeral services for his mother, Lydia Harris, who died in 1918, were officiated by Reverend Walter Taylor of the First Unitarian Church of Jamestown. Likewise, in 1952, Rev. Ralph N. Helverson, of the First Unitarian Church of Ithaca, officiated at Harris' funeral.[86] There is, however, no record in the archives of the First Unitarian Church of Ithaca to indicate that Harris was a member of that church, at least not an active member.[87] Judging by her letters, early in their relationship, certainly by the time Gilbert returned home for his father's funeral, if not before, Clara realized that religion was important to him. Nevertheless, there are few references to religion in any of Harris' writings or letters.

Clara's family appears to have had about the same kind of religious background, but one of her sisters was more involved in attending church and participating in its activities than Clara. In a letter to Gilbert, Clara describes Basie's work of teaching some Chinese workers to read and explains how she and a friend felt that after working all week, it wasn't right for Basie and her friend, Lillian Cook, to ride eight miles every Sunday to give them English reading lessons:

> "But you can't make Basie think it is anything but right. She would think she was not doing her Christian duty if she did not keep at it as long as she had a breath left."[88]

Clara seemed a bit concerned about her own lack of "church going". She said:

> "This morning when I ought to have been writing to you I was breaking the Sabbath by gathering hickory nuts."[89]
>
> "I suppose as it is the 5th of Oct., that you are enjoying a sermon at 'our' not 'your' church this evening. It has been so long since I have been to church that I fear I shall not know how to behave myself when I do go."[90]

While preparing for his upcoming wedding and trying to get his room in Washington, D.C. cleaned and refurbished for his bride, Harris had not overlooked his professional activity. In fact, he was very much involved with the large report that Dall was preparing:

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[80] Clara Stoneman to Gilbert Harris, July 6, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[81] Clara Stoneman to Gilbert D. Harris, September 13, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[82] Cora Harris to Gilbert Harris, May 11, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[83] The actual church affiliation is not known, but Harris' funeral services were held at the Unitarian Church in Ithaca, NY.

[84] Floy Harris to Gilbert Harris, July 20, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[85] Statistics for the Class of '86 list Harris as "Unitarian" and "Republican", but that he was, "not a church member."

[86] *Ithaca Journal*, December 5, 1952.

[87] Harris was not listed in the "Outstanding Unitarian Laymen" section of the booklet printed as part of the 75th Anniversary celebration of the church in Ithaca. Archives of the First Unitarian Church of Ithaca. Number 4590, Box 5, File 5-43 (Church History). RMC-KL, Cornell. Helverson did not recall Harris being a member of his church; letter to W. R. Brice, July 15, 1995. HA-PRI, Ithaca, NY.

[88] Clara Stoneman to Gilbert Harris, September 24, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[89] Clara Stoneman to Gilbert Harris, October 5, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[90] Clara Stoneman to Gilbert Harris, October 5, 1890. Private collection, WRB; now at HA-PRI, Ithaca, NY.

> "For the rest Mr. Harris has been busy collating and sifting the geologic literature of the Plio-Miocene under my direction, for the purposes of the prospective essay, which, as elsewhere mentioned has been carried as far as Virginia in the circuit of the coast. . . . In this matter [the correlation paper literature review] I have had valuable assistance from Mr. G. D. Harris, assistant paleontologist of the Division of Cenozoic Paleontology" (Powell, 1891a, p. 109–110, 112).

Then, as if he didn't have enough to do with his duties at the U.S.G.S. office, Harris prepared his second publication using data he must have acquired when he was at home for his father's funeral. The news that Clara sent him about the drilling activity in the area apparently started him thinking and when he was home he sought out the parties who were involved. He was able to see not only the drilling logs, but the actual samples as well because he wrote a description of the stratigraphic section exposed in the well which ended as a dry hole.

In writing the paper, he had the occasion to use the work of Charles Prosser who had been H. S. Williams' assistant the last year Harris was a student at Cornell. Harris recognized the scientific value of the material brought out of the hole during the drilling process:

> "During the early part of the season, a well was sunk at Jamestown, N. Y. to a depth of 3263 feet. For the proprietors, the undertaking was somewhat unfortunate, since neither oil nor gas—the objects sought—were met in paying quantities, to the geologist, however, the extensive suite of drillings carefully preserved and labelled, are of uncommon interest owing to the depth and peculiar location of the well; it furnishes him data for determining the lithological characters, thickness, and amount of dip in this region of several formations penetrated,—items heretofore but vaguely known from surface observations." (Harris, 1891a, pp. 164–165)

The date on the last page of this publication is December 1890, just before he left for Jamestown for a very important engagement. Gilbert and Clara were married on December 30, 1890[91] at her parents' home in Lakewood. A small announcement in the local paper datelined "December 30, Lakewood" said:

> "Tuesday at 12 m. Miss Clara Stoneman at the home of her parents, Byron Stoneman, was united in marriage to Gilbert Harris of Washington, D. C. They left on train 12 for Washington where they will reside, carrying with them best wishes of a host of friends for a happy and prosperous journey on the matrimonial sea. Rev. E. B. Barrows was the officiating clergyman."[92]

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[91] Palmer (1953c) gives the date of their marriage as December 29, 1890, but the page of marriages in the family Bible (Lopus and Ingham, 1977) has December 30, 1890. Also, the December 30 date is consistent with the marriage notice in the newspaper.

[92] *Jamestown Evening Journal*, Friday, January 2, 1891, p. 2.

CHAPTER 2. RETURN TO WASHINGTON

From the letters that survive, it appears that Clara and her new husband stayed in Washington, D. C. at a rooming house on 17th Street for a few months after they were married. She must not have gone out very much, however, because later, when she was at her parents home, a person who had some knowledge of Washington, D. C. commented about the buildings and asked her opinion about them:

> "The doctor who attends Pa was a soldier and has been in Washington and knows something about the city and surroundings. He was asking me if I had been to Arlington and some other places. Of course I had to say I had not. 'Well,' he said, 'you have been rather domestic, haven't you.' Then he said that the public building, such as the P.O. and Freemasonry, etc. were interesting places to visit. I said, 'Yes', but I did not tell him I had not been there either." [1]

But their brief trial at domesticity came to a close when field season began, for Harris had his geological activities and was off to the shore again to continue the work from the previous year.

Exactly where Harris was and what he was doing during this period are unclear for he was really moving from place to place. After some time in Washington, D. C., he went to Maryland, then Jamestown, New York for the birth of his daughter, then to Arkansas, back to the Maryland shore, and finally back to Washington, only to lose his position with the U.S.G.S.

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[1] Clara S. Harris to Gilbert D. Harris, July 23, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

Dall's report for 1890–1891 said this about Harris' travels:

> "In April [1891] Mr. G. D. Harris was detailed to accompany the State Expedition, under the auspices of Johns Hopkins University, directed by Prof. W. B. Clarke, which visited many important Tertiary outcrops of the Maryland shore.
>
> "On the 26th of May [1891], Messrs. Harris and [Frank] Burns were directed to proceed to Easton, Maryland, to examine the Tertiary rocks and obtain specimens from localities frequented by Conrad and other older paleontologists. The results of this expedition, though satisfactory, are not yet reported in detail, and a statement of them is therefore impracticable at the present time." (Powell, 1891b, p. 117).

Harris was working along the Bay shore of Calvert County, tracing:

> ". . . every important stratum represented in these cliffs from its northernmost outcrop to where its southern dip carries it beneath time level." (Harris, 1893a, p. 21).

Harris discovered that several observations made much earlier by Conrad were not quite correct:

> "Conrad doubtless examined this locality somewhat hastily, insomuch as several fossiliferous beds occur in the sand and clay regarded by him as 'destitute of organic remains.'" (Harris, 1893a, p. 22).

In the publication about the fossil strata of the Calvert Cliffs that resulted from his labors in the springs of 1891 and 1892, Harris said in a footnote:

> "The field observations upon which this essay is based were made under the auspices of the U.S. Geological Survey, April 23-30, 1891, and May 23-June 1, 1892. During the latter period, the writer was accompanied by Mr. Frank Burns, whose diligence and skill at collecting very materially aided in procuring the results here presented." (Harris, 1893a, Footnote, p. 21).

Harris left a diary describing the excursion of the April, 1891.[2] In addition to the U.S.G.S., the expedition included people from the State College of Agriculture and Johns Hopkins University. The party left Baltimore on April 23rd and travelled by the state police steamboat, *Gov. P. F. Thomas*, to Annapolis where two schooners were taken in tow and the group spent the first night lying off Fair Haven. As with most of Harris' descriptions of his journeys, he gets right to the geology:

> "Friday,a.m. April 24.—Breakfasted at an early hour in the open air, and rowed to the Fair Haven wharf. Some bluish clays of doubtful age were noticed just above the wharf, but the main interest centered in the bluffs of Miocene sands and clays and diatomaceous earth about a mile below the wharf, or about one fourth mile below where a creek makes into the Bay. . . . Having returned to the wharf, our attention was called to a boulder lying upon the beach about one fourth mile below the same. It contained numerous casts of Mollusks, and was said by N. H. Darton to be from the silicious layer that characterizes the very base of the Miocene."[3]

According to Harris' notes the group continued down the Chesapeake Bay making stops along the way to examine the exposures and collect fossils. By Saturday evening, April 25th, the group had reached Jones Wharf on the Patuxent River:

> "Below this wharf the low bluffs afford some good fossils, and during the forty minutes spent there no time was squandered."[4]

At times Harris appears frustrated with the pace of the excursion, not allowing him enough time to fully describe and explore an exposure:

> "April 28, 1891. The wind which had been blowing from the south during the fore part of the night had shifted by morning to the northward and was rolling in a fairly heavy sea upon us. Never-the less [*sic*] the row-boats were lowered and we were all safely landed at the base of Nomini Cliffs. Below the place of landing, which was about mid way of the cliffs, the writer made a section, but as the rest of the party were going up stream he was obliged to hasten away in the same direction without having made a collection of any sort." [5]

They collected fossils and examined the strata near St. Mary's, in the Pope Creek area, and along the banks of the Potomac River. During the stop at Clifton Beach, one of the party found what was described only as a "saurian tooth" with a fragment of the lower jaw. After a side trip to Mount Vernon, the group returned to

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[2] *Miocene of Maryland* (Cover title); *Notes on a Geological Excursion in Western Maryland*, by G. D. Harris, 1891 (Inside title page); an unpublished manuscript describing the field excursion of April 23–30, 1891, including many measured sections and fossil lists. There is no indication of when Harris wrote the manuscript or for what purpose. This manuscript is bound with typed copies of fossils descriptions and illustrations from Volume VI, Part I (1829) and Part II (1831), *Journal of the Academy of Natural Sciences of Philadelphia*. HA-PRI, Ithaca, NY.

[3] *Miocene of Maryland* (Cover title); *Notes on a Geological Excursion in Western Maryland*, by G. D. Harris, 1891 (Inside title page); unpublished manuscript, p. 1. HA-PRI, Ithaca, NY.

[4] *Miocene of Maryland* (Cover title); *Notes on a Geological Excursion in Western Maryland*, by G. D. Harris, 1891 (Inside title page); unpublished manuscript, p. 2. HA-PRI, Ithaca, NY.

[5] *Miocene of Maryland* (Cover title); *Notes on a Geological Excursion in Western Maryland*, by G. D. Harris, 1891 (Inside title page); unpublished manuscript, p. 3. HA-PRI, Ithaca, NY.

Washington, D. C. on Thursday, April 30. In Part II of this manuscript, Harris provided drawings of the sections with thicknesses of each major layer and he gives a list of the fossils found at each site. Many of the sites described in Part II are given site numbers, *e.g.*, the section at Nomini Cliffs mentioned above is number 2344. These numbers appear to be U.S.G.S. locality numbers which accompanied the fossils collected at each site.

Apparently Dall sent Harris to do other field work after he completed his investigation of the area at Calvert Cliffs, for a letter Clara sent from Washington, D. C., dated May 31, 1891, was sent to him at Easton, Maryland. Thus he must have moved on to the Eastern Shore of the Chesapeake Bay by the end of May. According to Clara's surviving letters, he stayed at Easton, Maryland at least through June 12th.

In this letter she sent from Washington on May 31st, Clara wrote that she had shared their secret with her family:

> "I have just finished a letter to Basie [her sister], in which I enclosed a private note telling of a certain family matter. I thought it better to tell them this early because I wanted them to use a little discretion about informing inquiring friends when I going to be at home. I am glad at any rate that it is off my mind and I am anxious, too, to know what they will say about it."[6]

The "it", of course turned out to be their daughter, Rebecca Stoneman Harris, born October 21st, 1891. She was probably named after Clara's Aunt Rebecca, wife of her father's brother, who died just a few weeks before their daughter was born[7]. The "special news" did not surprise too many in her family, however:

> "I received a letter from Basie yesterday written more especially, I guess, because of the 'private' communication which my last letter contained. She had not been home yet so I do not know yet what Ma will have to say on the subject. It seems, however, that the news was not at all unexpected and I did not much think it would be. She did not intimate, in the least, that the news was at all unwelcome either, as I was afraid it would be."[8]

And later, after she had been visiting his home, she discovered that Gilbert's family was quite happy. ". . . with the prospect of a new relation."[9]

At this point they were living in a rooming/boarding house at 1020 17th Street, N.W., for Clara mentioned getting one of his letters, ". . . when I went down for breakfast.". She also mentioned several other people getting mail at the same time: "Theresa got some letters and a bundle and Mrs. W. [the landlady] a letter . . ."[10] Their budget must have been somewhat limited, for in one letter Clara said that she had been invited on an excursion with some of the other boarders, but declined the offer:

> "They asked me if I would not go but I hardly think it would be advisable either financially or physically."[11]

She was sending him money for his expenses while doing the field work:

> "I hope that you have received my letter containing the money before this time, and that my failure to send it before has not caused you serious inconvenience."[12]

Their living expenses at the time seem modest:

> "I paid Mrs. W. this morning for our board. It was $17.00, or will be when I pay her the two dollars that I did not have change for this morning. It was really $17.50 but she said she wouldn't take the $.50 as I staid [*sic*] here thro [*sic*] the days and got my meals the best way I could."[13]

For what period of time the $17.00 covered is unknown. Also, whether from necessity or custom, Clara was making some of her own clothes:

> "I have finished my gingham dress, and let out the seams in my black waist [blouse]. Does such feminine news interest you?"[14]
>
> "I went down town this morning and bought me a white waist to wear with my white dress skirt so that I might get some good of that. I can also wear it with other skirts if I want to. I also bought 20 yds. of *bird's-eye linen*. Can you guess what will be made of that?" [Emphasis in the original.][15]

But there must have been a little extra money available:

> "Last Friday eve. we all went to see The Gondoliers. Miss A., Theresa, May and myself went and left Mr. & Mrs. W. at home but when we came out of the theater whom should

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[6] Clara S. Harris to Gilbert D. Harris, May 31, 1891. Private collection, WRB; now at HA-PRI,Ithaca, NY.

[7] "We received a telegram today telling that Aunt Rebecca was dead." Clara S. Harris to Gilbert D. Harris, September 10, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[8] Clara S. Harris to Gilbert D. Harris, June 5, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[9] Clara S. Harris to Gilbert D. Harris, July 30, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[10] Clara S. Harris to Gilbert D. Harris, June 5, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[11] Clara S. Harris to Gilbert D. Harris, May 31, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY

[12] Clara S. Harris to Gilbert D. Harris, June 5, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[13] Clara S. Harris to Gilbert D. Harris, June 10, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[14] Clara S. Harris to Gilbert D. Harris, June 5, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[15] Clara S. Harris to Gilbert D. Harris, June 6, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY

> we see waiting for us but Mr. & Mrs. W. Mrs. W., you know, doesn't approve of Jeannie Winston. For my own part I did not see much to admire in her. I did not enjoy her acting the part of a man because I could not forget that she was a woman. Not that I was shocked in the least but I could not see any reason for her taking that part."[16]
>
> "And I squandered 10 cents on a pint of cherries, which was quite extravagant I suppose, but I was so thirsty and they looked so cool I couldn't resist the temptation."[17]

While these prices seem trivial by the standards of 100 years later, they were not small at the time. The couple must have been on a tight budget and money was a constant worry. For example, money matters surfaced in one of Clara's letters to Gilbert while she was staying with her parents before Rebecca was born. In a previous letter Clara had requested he send her some postage stamps (which he did); he apparently assumed she was asking, in a roundabout way, for some spending money:

> "Your kind letter of August 1st containing the money reached me without any accident on Monday P.M. I am much obliged for the money although I had no great need of it just now. I have not spent much of the $15 that I brought with me [almost a month ago]. Today Pa paid me back what I lent him to pay the men and now I have in all $24.25. That, I think, ought to be enough for my wants until you come and maybe longer so I do not believe you will need to send any money unless something unusual happens."[18]

Rollin and Emily Harris were in Washington as well and living close enough for Clara to visit with them while Gilbert was away:

> "Yesterday afternoon I went over to see if Rollin and Emily had entirely melted in to grease spots. They were usually well. Emily had been canning strawberries. She was trying to keep as cool as possible by not wearing any more clothing than the law requires. I staid [*sic*] to dinner with them and had quite a visit."[19]

By July 14, 1891, Clara was with her parents in Harmony, New York and Harris was back in Washington, D. C. This separation was especially difficult for Clara as she was in the sixth month of pregnancy and away from her husband for the first time since their marriage:

> "Doesn't it seem longer than two weeks since I left Washington. I haven't *had my back scratched* since I came home. It's getting pretty itchy. Don't you pity your poor wife?" [Emphasis in the original.][20]

He, too, must have been expressing his feelings about the difficulties of their separation, for in one of her letters, Clara wrote:

> "My poor boy, I know just how hard it is to be alone as you are and I would be glad if I could get a letter to you everyday but I can not [*sic*]. I am very sorry you have worried so much about me. I am perfectly well and you may be sure if anything unusual should happen you would be informed as soon as possible. . . . My darling I do appreciate how much you love me and am very grateful. Please don't worry yourself sick."[21]

There was reason for his concern because at one point she complained of a bad rash on her feet that caused strong itching and swelling:

> "You ask in regard to the state of my health. My digestive organs are in very good order. . . . Just now, however, I am about distracted on account of my feet. They are quite a good deal swollen and all along the sides of my foot and toes especially little hard bumps swell up and burn and itch terribly. The lumps on my toes are in ridges. They do not come out like mosquito bites but seem to be under the skin. My hands began to be the same this morning but do not trouble me now. If they do not get better I shall have to go to the Dr. I expect. They burn so now that I can hardly keep still to write."[22]

Four days later her feet were still swollen:

> "I sent with Basie yesterday and got me some cloth slippers,—No. 6. Of course they will be too large when the swelling goes down out of my feet."[23]

Clara, in fact, did little to allay his fears for her health, and often included just enough information to really start him thinking:

> "I am feeling about as well as usual. My hands and feet trouble me a little yet but now I am troubled some by dizzy spells and I cannot read or do anything evenings because I get so nervous and my head feels so. I guess it is nothing very alarming. Only think there is only a little over one month more to wait!"[24]

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[16] Clara S. Harris to Gilbert D. Harris, May 31, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[17] Clara S. Harris to Gilbert D. Harris, June 6, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[18] Clara S. Harris to Gilbert D. Harris, August 5, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[19] Clara S. Harris to Gilbert D. Harris, June 5, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[20] Clara S. Harris to Gilbert D. Harris, July 26, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[21] Clara S. Harris to Gilbert D. Harris, August 15, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[22] Clara S. Harris to Gilbert D. Harris, August 19, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[23] Clara S. Harris to Gilbert D. Harris, August 23, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[24] Clara S. Harris to Gilbert D. Harris, August 28, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

Perhaps Harris had good reason to worry, for the infection on her feet continued to trouble her well into September:

> "I feel well enough but the weather is so warm and my feet still trouble me so that I feel decidedly uncomfortable most of the time."[25]

This sharing of illnesses was a two way street, however, for in early September of 1891, Clara wrote:

> "I do not like to hear of your recent sickness. I hope that you will do all you can to prevent it becoming a serious trouble. What is the cause of it?[26]

In an earlier letter Harris must have offered to hire someone to look after her if only she would return to Washington. Her reply:

> "I hardly know how to begin to say what I want to say, though first I know you will be dreadfully disapointed [*sic*] if I say I do not believe it would be best for me to go back to Washington as you want me to do. But really, Gilbert, I do not think it would be best and it might be just the thing that would make trouble for me. It hardly seems to me it would be best to go to the extra expense hiring nurses, etc. as long as I am right here now where both our families are. Of course I know that you would be willing to pay all the extra cost and it would be very, very pleasant to be with you again as you suggest and I know you could not help being anything but the best of husbands, but only think, dearest, I have already been here more than half the time that will have to elapse before you can come home, so it does not seem to me, at all, to be the best policy to go back to Washington when everything is taken into consideration. I told Ma that you wanted me to come back to W. and she said, 'Well you are not going.' Don't worry about my having to work, it's my own fault if I do it because they all tell me not to and I have not done so much this week . . ."[27]

While visiting his mother and sisters outside of Jamestown, Clara wrote:

> "I have enjoyed my visit here so far and don't feel homesick or lonesome only it doesn't seem right to be here without you. I look towards the barn every once in awhile and it seems as though that little door ought to open and you come forth in your 'regimentals'—blue 'frock' and 'overalls', muddy boots and military cap. But, alas I can look as often as I will, I won't see you."[28]

And added to her loneliness was the fact that her father was quite ill:

> "Oh! how I do wish I knew how you are this morning. I am made aware by a certain feeling in my throat that I can't let my thought move in a certain direction or I would be crying in short order and that wouldn't do at all. . . . I could be comparatively happy here [at home] if it were not for the fact that Pa is very sick again. He is not as bad off as he was at the worst last fall but I am afraid that some of his symptoms are a great deal worse. I don't like to think of it but I am afraid he can't possibly last much longer. . . . I did not sleep much last night for just as I would get to sleep Pa would begin to groan and that would wake me up. . . . I do hope you are well, my dearest one. You may be sure I shall not forget you and that my thoughts go back very, very often to that room at 1020 17 St. and wish that I was there."[29]
>
> ". . . Pa requires a good deal of attention. I hardly know whether to say that he is better or not. He does not seem to be in quite as much pain, but he is still very weak and, oh, so nervous. He likes to have somebody by him all the time and especially when he awakes from a nap if he sees that someone is sitting by him he does not get so weak and nervous. I have staid [*sic*] by [him] all that I could day times because I can't do much work nor sit up nights. . . . Pa's mind wanders a great deal, although at times it is as clear as ever. He talks about the [Civil] war mostly. The other day he told Basie that there ought to be lots of white lead on hand so that the hired men could make bullets."[30]
>
> "Pa continues about the same. He walks out a little but is not able to attend to the work at all. He lies in bed most of the time."[31]

In many of the letters Clara keeps referring to their child as "Robert."

> "This morning I weighted 143 lbs. Some of that may be 'Robert', however. . . . Ma says I can't have a 'Robert', I must have 'Bryon' . . ." [her father's name][32] "I think Robert is prospering."[33]

As the time of birth drew near, however, Clara began to acknowledge the possibility of a girl, perhaps twins, and the name Rebecca is mentioned:

> "Robert and I weigh *155 lbs.* I don't know but I ought to say Robert and Rebecca. Basie says I ought. The other day

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[25] Clara S. Harris to Gilbert D. Harris, September 25, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[26] Clara S. Harris to Gilbert D. Harris, September 2, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[27] Clara S. Harris to Gilbert D. Harris, August 20, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[28] Clara S. Harris to Gilbert D. Harris, July 30, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[29] Clara S. Harris to Gilbert D. Harris, July 14, 1891. Private collection WRB; now at HA-PRI, Ithaca, NY.

[30] Clara S. Harris to Gilbert D. Harris, July 16, 1891. Private collection, WRB; now at HA-PRI-Ithaca, NY.

[31] Clara S. Harris to Gilbert D. Harris, July 26, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[32] Clara S. Harris to Gilbert D. Harris, July 16, 1891. Private collection, WRB; now at HA-PRI-Ithaca, NY.

[33] Clara S. Harris to Gilbert D. Harris, July 26, 1891. Private collection, WRB; now at HA-PRI-Ithaca, NY.

> she found an ear of green corn that had two small ears growing with the same husk. She considered that a very favorable omen of coming events." [Emphasis in the original.][34]

The idea of twins struck a responsive chord with Clara because several weeks later she wrote to Gilbert:

> "This afternoon I went out to the corn farm to try Ma's standard of measurement. She said that the summer before Basie was born she could get through the corn . . . [rows] . . . as easily as could be. I could not begin to do so. What if Robert would happen to have a brother or sister come along to keep him company! Or possibly more than one!! Then I guess you would have to stay at home evenings to help hold him. You could not go to see 'Sally' as any one else." [Emphasis in the original.][35]

One can only wonder about the reference to "Sally."

In many ways being at home again with her family was good for Clara, but at the same time her status had changed; now married and pregnant:

> "Everything seems quite natural here although I do not think it seems quite the same as it used to before I went away and I expect the reason is because I am not able to go ahead and work and drive [the horse and wagons] around as I used to. . . . I soon remember that I am not expected to do so and about every move I make either Basie or Ma tells me to go and sit down, that I need not do that. . . . Pa evidently thought I might lend a hand . . . [filling the water wagon] . . . for when I went into his room he said, 'I don't want you to do any pumping.'"[36]

Upon her return home, however, some friction appears to have developed between Clara and her sister, Basie. Perhaps with Clara gone, Basie was suddenly cast in the limelight and liked the new role, and with Clara back in the house Basie's new position in the family was threatened. In one letter Clara related to Gilbert:

> "This morning Basie said to Marian that the work had seemed so short and I remarked that it had not seemed so to me but that it had been a dreadful long time since Monday. 'Oh!' Basie said, 'you old married woman you. I wouldn't be an old married woman for anything!' "[37]
>
> ". . . I wouldn't feel bad when going away. Basie said, 'Feel bad about going away! Why I supposed you would be so anxious to get home that you could hardly wait.' She was telling Ma this morning that she guessed I was thoroughly weaned. I know I ought to be ashamed of myself, but if I had not a good reason for staying here I could cut my visit pretty short."[38]

And at another time, Clara said:

> "This morning I mentioned a certain thing that I must do before going 'home' and Basie says, 'Don't you think you are smart, don't you'"[39]

Apparently her sister felt that Clara should not refer to Washington, D. C. as "home." Even the sleeping arrangements had changed. Whereas before her marriage she shared a bedroom and bed with her sister Basie, but now:

> "As for sleeping I think I told you that I sleep all by myself in the 'guest chambers'. I get up and go to bed when I please."[40]

Even Clara, herself, had difficulty adjusting to her new status:

> "At the grocery [store] the man asked me what my name was and I told him 'Stoneman.' I did not think but what it was until after I had said it and then I did not think it best to explain matters."[41]

In late July of 1891, Clara visited Gilbert's home at "Peck Settlement" for a few days and sent him several letters from there. From her letters, it seems there were street cars operating in the Jamestown vicinity, but not everyone had adjusted to this new mode of transportation:

> "I came from Lakewood on the boat and thence to Dexterville on the new electric cars. . . . I can't see that your folks have bettered themselves on the horse question very much because their horse is old and doesn't go at a 2:40 gate especially away from home and is more afraid of the [electric] cars, besides, than 'Bennie' was."[42]
>
> "Cora brought me over to D.[Dexterville] and I rode from there to the boat landing on the street cars. They are still a great novelty to the Jamestown people. They think it very strange that they [the street cars] will not stop anywhere except on a crossing and the teamsters seem to think they have a perfect right to drive on to the track and stand there until it suits their convenience to get off."[43]

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[34] Clara S. Harris to Gilbert D. Harris, August 30, 1891. Private collection, WRB; now at HA-PRI-Ithaca, NY.

[35] Clara S. Harris to Gilbert D. Harris, September 13, 1891. Private collection, WRB; now at HA-PRI-Ithaca, NY.

[36] Clara S. Harris to Gilbert D. Harris; July 23, 1891. Private collection, WRB; now at HA-PRI, Ithaca NY.

[37] Clara S. Harris to Gilbert D. Harris; July 16, 1891. Private collection, WRB; now at HA-PRI, Ithaca NY.

[38] Clara S. Harris to Gilbert D. Harris; July 21, 1891. Private collection, WRB; now at HA-PRI, Ithaca NY.

[39] Clara S. Harris to Gilbert D. Harris, July 26, 1981. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[40] Clara S. Harris to Gilbert D. Harris, July 23, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[41] Clara S. Harris to Gilbert D. Harris, July 26, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[42] Clara S. Harris to Gilbert D. Harris, July 26, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[43] Clara S. Harris to Gilbert D. Harris, August 2, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

Based on a letter Clara wrote to Gilbert in August of 1891, his position with the U.S.G.S. at the Smithsonian must have seemed fairly secure. He had just completed another paper for publication (date on the last page is August 1891; Harris, 1891c), and the Arkansas material had been published or was about to be published (Simonds' letter about it, mentioned earlier, was dated September 21, 1891). At this point, by letter, they began discussing having a home in Washington. The strength of her character can be seen in this excerpt, for it appears Gilbert had either hinted or asked her directly to approach her father for a loan (gift?) to assist them in getting a house:

> "In regard to what you have written about your thoughts and plans for a home in Washington you may be sure that I will agree in wanting to have a home there as soon as possible, but I can not [*sic*] say I would be willing to ask my father for the money at the present anyway. If it was very necessary, I could do it, but I would rather not be obliged to do so. Of course I understand perfectly, Gilbert, that you would not expect to 'sponge' the money so do not think I hesitate on that account. In the first place Pa's money is all out in mortgages, at present, except that which he needs for the various expenses which is no small amount,—and then, I know to [*sic*] well how much trouble it would make. I hope you will not be provoked at me for not liking to do as you wish, but I thought it best to tell you on the start just how I feel. By your letter of the 30th, I understood you to mean you wanted to have a house built so that we could go there to live this winter. Do you think that would be possible and are you sure it is the best plan to try to do so? And do you think it would be cheaper and better to build a house than to buy one outright? Do not think I ask these questions expecting you to think I am opposed. I am not but I wish to understand the subject a little better."[44]

His reply must have been quite persuasive, and he must have told his family about his plan for a house in Washington and the need for money to finance it, for in letter written only a few days after the one quoted above, Clara said:

> "I feel ashamed of myself to think I can't do more to help you in your plans for getting a home in Washington. As long as I can't or don't do more as you would wish, I don't deserve your kindness in having the deed of such a lot as you will get made out in my name. I would feel better about it if it were not so. I have spoken to Ma and told her something of what you have in mind and she told me what I knew well enough before that all the money Pa has is in mortgages. I believe he has a few hundred in the bank but that he needs for paying taxes, hired men, etc. However, if I have a chance when he is not too much worried over other things, I will try and talk with him on the subject.
>
> "As I did not know what you had in mind while I was at your mothers [*sic*] I had no occasion to talk with her about your plans and I may not have another chance very soon, maybe not before you come home, but if you have already written to your folks I do not know what more I could say that would have any influence. I suppose you will be about discouraged and think I am pulling right against you. I don't wish too [*sic*] and if it seems so to you it is not from obstinacy."[45]

Their living arrangements after the birth of their child were very much on Gilbert's mind and he must have communicated this concern to her. But once again, Clara's determination to say what she feels comes through:

> ". . . [this] brings me to the point of our housekeeping arrangements for the coming year. You speak of my not liking to live out of the city. I suppose it would be lonesome at first but I would be perfectly willing to live wherever it seemed best even though I did have to undergo some discomfort. However, for the next year perhaps it would be better for us to live a little nearer friends. It would be more agreeable and safer perhaps in case of an emergency."[46]

Apparently though, Gilbert was not to be deterred by a simple refusal of his first few plans, for in a letter about a week later, Clara responded to yet another option from him about where to live after the baby was born, and, again, she was quite firm about her desire to stay with her parents in the meantime:

> "As to renting a house with R & E. [Rollin and Emily, her brother- and sister-in-law] that would suit me exactly. I think we could manage to 'live together in brotherly love.' Now, darling, please do not scold me nor feel hurt because I do not agree with you in this respect . . .
>
> "I know I have not answered your letter satisfactory [*sic*] but I hope you will try and be satisfied with my decision [to stay at her parents until the baby is born]. . . ."[47]

Her decision not to rent a house with Rollin and Emily seemed to have upset them, for later she wrote to Gilbert:

> "I am very sorry if I have been the means of dissapointing [*sic*] R. & E. about renting the house you and they had in

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[44] Clara S. Harris to Gilbert D. Harris, August 2, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[45] Clara S. Harris to Gilbert D. Harris, August 5, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[46] Clara S. Harris to Gilbert D. Harris, August 12, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[47] Clara S. Harris to Gilbert D. Harris, August 20, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

> view but I did not see how I could do otherwise. I hope you will forgive me, dear."[48]

With their domicile for the next year still undecided, Harris proposed the idea of buying a building lot in an area outside of Washington, D. C. near Ft Meyer, Virginia.[49] He continued his attempts to persuade Clara to come back to Washington, even by telegram. She replied:

> "Gilbert, my dearest one, what has taken possession of you? When I left Washington I thought it was fully understood by both of us that I was to remain north, either at my own home or at yours during October and as long after that as seems best. Now, my darling, why can you not be contented with that arrangement? I certainly have been more comfortable here where I could go as I pleased in my old house clothes and where, if there was any cool fresh air blowing I could have the full benefit of it. It does not seem to me that I could possibly have stood it all this time to have had to dress up and go to Ditto's three times a day to my meals. . ..I would be glad if I could go to you this very minute but I cannot, it would be entirely out of the question.
>
> "Your telegram was not received until 9 o'clock Friday night. Julia brought it from Lakewood. It was answered as soon as possible. You have probably received your answer before this time and feel like shaking the whole Stoneman tribe, your Mother-in-law in particular. She opposed the idea of my going back from the very first. Pa was not told anything about the telegram as he was altogether to [*sic*] sick to be troubled in anyway."[50]

Thus it was; Clara did not return to Washington, but Gilbert had still other plans afoot:

> "Now my dear, I want to know about this new plan of yours of going to Arkansas. That is an entirely new feature of the case. Are you going with White[51] or Prosser? I don't want you to go at all but I suppose it is for you to decide whether you will or not. But, my dear, if you do go don't you see that it will be a great deal better for me to be here where I can have the advice and help of both my mothers than to be in Washington comparatively alone. And besides, I have various things I want to do that I shall not be able to do before Robert comes. By the way he is rather lively today."[52]

The Arkansas venture would mark Harris' return to that state, but his new venture differed from his first one because this time he was employed by the U.S.G.S. and was part of a cooperative agreement between the state and federal surveys. In the Annual Report for 1891–92 of G. K. Gilbert, Chief Geologist, the following items concerned the Arkansas work:

> "The expense of this work [cooperative agreement with the Arkansas Geological Survey] was shared by the state survey and the national Survey, and it was executed by Mr. G. D. Harris, assistant paleontologist, who was detailed by the paleontological branch for that purpose. The field work which occupied the months of November and December 1891, and January, 1892, included supplementary determinations of stratigraphic sequences in Arkansas and the collection of numerous fossils for comparative study." (Powell, 1892, p. 95)

Even while he was planning to leave, he was worried about his wife and she was writing to reassure him: "I wish I knew of some way to prevent you from worrying yourself in to such a nervous state."[53] Apparently his worrying did not prevent him planning the field work in Arkansas. Of course, as he was an employee of the U.S.G.S., and based on the above quotations, it appears he may not have had too much choice in the matter.

As it turned out Clara supported his decision and found a good reason for him to do the Arkansas work:

> ". . . [I will] come to the 'point' and tell you what I think of your plans. Under the circumstances I do not see how they could be better. I imagine that the time will pass more quickly with me to be here than it would to be in W. while you are away and as long as I can not [*sic*] very well go back to W. much before Christmas any how I should think the time would go sooner for you if you have a change of scene and work. I hope you will not have to work as hard as you did before though."[54]

During this separation before the birth of their child, while commenting about a professional meeting he attended, Clara did not miss the opportunity to offer additional support for her decision to stay at home:

> "I am glad you are having such a good chance to see your friends from the different parts of the country. Why does not Prof. Simmonds [*sic*][55] attend the meetings? (I have forgotten how his name is spelled, but you know whom I mean.) It may be a good thing for you on one account,

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[48] Clara S. Harris to Gilbert D. Harris, August 28, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[49] Clara S. Harris to Gilbert D. Harris, September 10, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[50] Clara S. Harris to Gilbert D. Harris, August 23, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[51] Charles D. White, a former classmate of Harris' and later director of the U. S. Geological Survey.

[52] Clara S. Harris to Gilbert D. Harris, August 23, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[53] Clara S. Harris to Gilbert D. Harris, August 23, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[54] Clara S. Harris to Gilbert D. Harris, August 25, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[55] Frederick W. Simonds, with whom Harris worked in Arkansas in 1888 (Palmer, 1953c).

> that I am not in Washington just now. If I were I could not attend the receptions, . . . and for that reason I am afraid I might prevent you from going whenever you would like."[56]

At this time Harris and Dall were completing the final portions of their Neocene volume which was published in 1892. According to Palmer (1953c), in 1890–91 J. W. Powell, Director of the U.S.G.S., had given Dall the task of preparing a memoir on the Neocene [now called Neogene] deposits of the U. S., and Dall had assigned Harris part of the work. This was to be one of a series of "Correlation Papers" the Survey was producing which summarized the state of the stratigraphic knowledge at that time. Previous work had been published on the "Carboniferous and Devonian" (Williams, H. S., 1891), the work that led to the creation of the Mississippian and Pennsylvanian subdivisions of the Carboniferous strata in North America; "Cambrian" (Walcott, 1891); "Cretaceous" (White, 1891); and "Eocene" (Clark, 1891). The work on the Tertiary that Dall and Harris were doing was published as the "Correlation Papers: Neocene", (Dall and Harris, 1892). The division of labor is given in the introductory remarks in this paper:

> "As regards the division of labor between the senior and junior authors of this paper, it may be stated that the work of searching the literature and bringing together the scattered data relating to particular states or regions has been largely performed by Mr. Gilbert D. Harris. For the revisions and correlation of this material and for the whole of the chapters on Florida, British Columbia and Alaska, and the general discussions embodied in the essay, Mr. Dall is responsible. The list of formations, which, short as it is, has cost much labor and correspondence with authors who have proposed the names, has been prepared by Mr. Harris, who has prepared the chapter on the Interior regions." (Dall and Harris, 1892, p. 17).

Harris' chapter on the Interior region covered only pages 280–317, thus Dall prepared most of the manuscript, but Harris' labor was extensive and did not go unnoticed by Dall, or by G. K. Gilbert. In the *12th Annual Report*, Gilbert noted that Harris' contribution had been extensive and vital:

> "Much of the labor of compilation was performed by Mr. G. D. Harris, and the importance of his contribution has been recognized by giving place to his name on the title page as junior author." (Powell, 1891b, p. 64).

Gilbert repeated this praise in the 1893 report as well:

> "Dr. Dall was assisted in the work of literary compilation and in many other ways by Mr. Gilbert D. Harris, and this assistance proved of such importance to the successful prosecution of the work that he deemed it a matter of justice to associate Mr. Harris's name with his own on the title-page of the book." (Powell, 1893, p. 183).

The need for an extensive literature search evidently made an impression on Harris, however, for many of his subsequent works include a detailed literature review, *e.g.*, his paper on the Midway Stage (Harris, 1896a). Later as a teacher, he instilled the idea of a thorough literature search in his students, and they followed his model as can be seen, for example, in Maury (1925), Olsson (1934), and Palmer (1937).

Based on Clara's letter, Harris must have been quite busy trying to complete the final work on the Neocene volume and work on the Tertiary collections, all before he left for Arkansas. She wrote to him:

> "My dear you are trying to compress a good deal of work into a few weeks! I thought that you said your plan of arranging the Tertiary collection would take you several years but now you say Dr. Dall wants you to do it before you go away this fall."[57]

As the time of fatherhood drew closer, Harris seemed to have really taken the idea to heart and looked at parenting as a real partnership. Ever the organizer, he apparently set out a table of housekeeping duties he was to do for her:

> "After reading your letters I could not help but think how lucky I am. When I go back to Washington I shall have nothing to do but to fold my hands and enjoy myself because I shall have a husband 'to do my cook.' I hope you will become an expert at marketing. Your housekeeping program seems to be very good so far as it goes but I do not see any *dishwashing* [*sic*] number upon it. How about that part?" [Emphasis in the original.][58]

As to Harris' movements around this time, some letters help establish his whereabouts. A letter to Harris at the Smithsonian from Frederic Simonds about the Arkansas publication from the 1888–1889 work is dated September 17, 1891 and postmarked in Washington, D. C. on September 21st. Thus, in late September or early October, Harris must have gone to the Jamestown area to be with his wife during the last stages of her pregnancy and the birth of Rebecca Stoneman Harris, for her letters stop about this time and do not begin again until after the birth. Also in September, Harris published his fourth paper (Harris, 1891c).

The fact that Rebecca's birth on October 21, 1891, occurred in Ellicott seems to indicate that the couple stayed at his home. That is where the Harris family lived and where Gilbert himself had been born (Lopus and Ingham, 1977).

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[56] Clara S. Harris to Gilbert D. Harris, August 30, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[57] Clara S. Harris to Gilbert D. Harris, September 13, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[58] Clara S. Harris to Gilbert D. Harris, September 6, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

Harris must not have stayed with his wife and newly born daughter very long, however, as he received mail in Jamestown postmarked October 25th and October 26th, 1891, from two U.S.G.S. colleagues. The first was from T. W. Stanton, informing him that, "Dr. White was disposing of his library, . . .", and he said, also, "I hope you are enjoying your vacation." Stanton makes no mention of the fact that the real reason for Harris being in Jamestown, the birth of his daughter.[59] The second was from David White who did inquire about Mrs. Harris:

> "Why this silence for so long? What is the news? Neither Mr. Prosser nor I have had a line from you for a long time. . . . How is Mrs. Harris? When do you leave for Arkansas?"[60]

But on November 1, Stanton sent another letter about a book he had purchased for Harris. This one went to Little Rock, Arkansas, in care of J. C. Branner, who in turn forwarded it to Kingsland, Arkansas where Harris was headquartered in November.[61] Clara's letters were directed to him in Little Rock as well. In December one of her letters sent to Little Rock was re-directed to Cleveland County, so he must have been moving around.

From Clara's letters to him during his time in Arkansas it seems that once again, Harris was in poor health. The last time he worked in Arkansas he had also become quite ill. Despite all the ill health and work, however, he was writing to her almost every other day, and apparently he was not to stay in Arkansas very long:

> "I received your letter of the 12th [December 1891] on Friday and those of the 14th and 16th this . . . morning. . . . Letters are good in there [*sic*] place but I am so glad that the time is near at hand when they will not be necessary. . . .
>
> "They [his family] were somewhat worried I suppose because they have not heard from you since the letter saying that you were not well."[62]

The last surviving letter from Clara during his Arkansas activity is dated January 12, 1892 and in it Clara spoke of him delaying his departure, which, apparently, did not exactly please her:

> "Ma and Marian draw a long breath every time I get a letter and you still keep putting off the time for coming home. Not that they want you to stay away but they are afraid that every week you will be swooping down and carrying off 'Betty', as Ma calls Rebecca. She is just the dearest little girl and I do wish you could be here to watch her grow. I am afraid she will be 'a great big woman like her mother' by the time you come home."[63]

A letter from his sister, Floy[64], also sent to Little Rock, was dated January 17 and postmarked in Little Rock on January 20, 1892, so he was receiving mail in Arkansas during the closing weeks of January. A letter from his sister Ida dated March 3rd, however, was sent to their new residence at 1031, 8th Street, N.W. Washington, D.C. and the heading was, "Dear Brother and Sister,"[65] so they both must have been back in Washington, D. C. at that time.

Thus, Harris was in Arkansas from sometime in late October 1891 until late February or early March 1892, and he returned to Arkansas the following September:

> "The winter of 1891–92 was spent by the writer in southern Arkansas under the combined auspices of the United States and Arkansas Geological Surveys. The first part of September, 1892, was spent in reviewing work done along the Cretaceous-Tertiary boundary." (Harris, 1894b, p. 6).

In his report for 1891–1892, Dall gave these dates for the Arkansas work:

> "From September, 1891, to March, 1892, Mr. Harris cooperated with John C. Branner, State Geologist of Arkansas, in the Southeastern part of the State." (Powell, 1892, p. 143–144).

As described above, however, from dates and addresses on his letters, Harris must have spent part of that time in Jamestown to be with Clara at Rebecca's birth before going to Arkansas.

It was during these field activities in Arkansas during 1891 and 1892 that Harris did his first real work with Tertiary strata as he worked in a region south of the Arkansas River. He worked his way south all the way to the Louisiana state line and prepared a geologic map of the area (Palmer, 1953c). In the preface to the Arkansas report in which this work was published, J. C.

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[59] T. W. Stanton to Gilbert D. Harris, October 24, 1891. HA-PRI, Ithaca, NY.

[60] David White to Gilbert D. Harris, October 24, 1891, HA-PRI, Ithaca, NY.

[61] T. W. Stanton to Gilbert D. Harris, November 1, 1891. Stanton's letter was sent from Washington, D. C. to Little Rock, Arkansas and then forwarded to Kingsland. HA-PRI, Ithaca, NY.

[62] Clara S. Harris to Gilbert D. Harris, December 20, 1891. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[63] Clara S. Harris to Gilbert D. Harris, January 12, 1892. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[64] Floy Harris to Gilbert D. Harris January 17, 1892. Private collection, WRB; now at HA-PRI, Ithaca, NY.

[65] Ida Harris to Gilbert D. Harris March 3, 1892. Private collection, WRB; now at HA-PRI, Ithaca, NY.

Branner, Director of the Arkansas Geological Survey, described the significance of Harris' work:

> "The task undertaken by Professor Harris was not an easy one: the country with which he had to deal is one of low topographic relief and heavily timbered, the rock exposures that might otherwise have been expected are generally concealed by the disintegration and breaking down of the original beds, while the marked paucity of marine fossils throughout the entire region has added to the difficulty of the work. These obstacles, however, have been so well overcome that the present report, besides dealing with the general features and distribution of the Tertiary geology of the State south of the Arkansas River, brings out several new points of especial interest. Among other things Professor Harris has shown:
>
> 1. That the Midway beds of the Alabama section are the oldest of our Arkansas Tertiary rocks.
> 2. That the beds at Olsen's Switch, Pulaski county, from which *Enclimatoceras ulrichi* [a nautiloid] came are not Cretaceous but Tertiary.
> 3. That the Cretaceous beds, although not known at the surface, are penetrated by the wells at Beebe and Cabot.
> 4. That the Arkadelphia shales, referred by Hill to the Tertiary, are of Cretaceous age.
> 5. That the Cretaceous-Tertiary border from Arkadelphia southwest lies south of the St Louis, Iron Mountain and Southern Railway, and not north of it, as hitherto believed." (Harris, 1894b, p. XII–XIV).

The summer of 1892 found Harris back on the shores of Chesapeake Bay (Palmer, 1953c) (presumably leaving Rebecca and Clara in Washington). This is confirmed by Dall's report for 1891–1892; Harris was indeed back at the Maryland shore:

> "Mr. Harris paid a short visit to the localities in Maryland for the purpose of reviewing the sections made by Conrad nearly half a century ago, in which serious errors were suspected, and on inspection were actually found to exist." (Powell, 1892,p. 145).

Perhaps the errors Harris discovered the year before prompted this return visit. This work did not take him very long; as indicated in an earlier quotation from the Calvert Cliffs publication, he worked on the Chesapeake Bay shore from, May 23–June 1, 1892. And around the middle of June he received a letter dated June 13 which was sent to Washington, D. C.[66] The work along the Bay which Harris started in 1891 and completed in 1892 was published in 1893 as *The Tertiary Geology of Calvert Cliffs, Maryland* (Harris 1893a). He later used other portions of his observations in Maryland in general paper about the Eocene beds of Maryland and Virginia (Harris, 1894a).

But Harris' days with the U.S.G.S. were numbered, for the depression of 1892 forced the government to reduce staff and Harris was one of these casualties. Or, as Harris himself said, ". . . curtailment in the affairs of the federal survey necessitated employment elsewhere of the younger members of that organization" (Harris, 1919, p.3). Based on Dall's year-end report for 1892–93, dated July 1, 1893, Harris must have left the U.S.G.S. shortly after he returned from the Arkansas work:

> "The report on the Arkansas Tertiary fossils for the state survey was finished by Mr. Harris before he left Washington, forwarded to Little Rock, and, I am informed, will shortly be printed." (Powell, 1893, p. 257).

Harris may not have found the change entirely unwelcome. Druid Wilson, a former student of Harris', recalled Harris telling him, with regard to his relationship with Dall, that, "I [Harris] could not get along with him [Dall], so I decided to get along without him."[67] That feeling, however, did not keep the two men from continuing a professional relationship that appears to have bordered on friendship. In a short paper he did about some of Dall's interpretation of Conrad's publications (Dall, 1893a), Harris said this:

> "There are, to be sure, several unsettled points relating to this work [Conrad's], but, no one is more capable of dealing with them than is Dr. Dall." (Harris, 1893d, p. 280).

And in a later publication, Harris was even more effusive:

> "It is certainly fortunate for American Tertiary Paleontology that there has been at the National Museum a man of Dr. Dall's erudition and sympathetic interests." (Harris, 1919, p. 3).

Judging from the various letters from Dall to Harris found in the Harris Archive at PRI, they continued to correspond. Even toward the end of Dall's life, there was communication between the two men as evidenced by a letter from Dall, at age 75, to Harris in 1920 which certainly had a personal and friendly tone to it:

> "Why don't you come up to the mountain [in New Hampshire] sometime next summer and study the turkey tracks in the metamorphic schists? I say they are pseudomorphs of some kind of reed, but some of the petrologists claim they are after crystals. But I never heard of jointed crystals sometimes three feet long with regular branches. Anyhow come and see us."[68]

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[66] A letter June 13, 1892 from [illegible] on Geological Survey of Arkansas letterhead but dated Des Moines, Iowa sent to Gilbert D. Harris addressed to Washington, D.C. HA-PRI, Ithaca, NY. This letter was found folded inside the Arkansas Survey Report for 1892 at PRI.

[67] Personal communication July 12, 1995.

[68] William H. Dall to Gilbert D. Harris, June 24, 1920. HA-PRI, Ithaca, NY.

So, now with a young daughter as well as a wife, Harris found himself unemployed. Yet he was not without prospects. According to Harris, around this time he received a recommendation from C. D. Walcott, who was the Chief Paleontologist and later the Director of the U.S.G.S.:

> "In '92, during one of those pseudo-economic, or political paroxysms that formerly afflicted our federal Geological Survey, the writer, an employé of that organization, very naturally found it necessary to seek other quarters where his work in Tertiary Paleontology could be advantageously continued. Through a recommendation of Chief Paleontologist Walcott (now Secretary of The Smithsonian Institution) such a haven was found on the State Geological Survey of Texas,[69] then being ably administered by Mr. E. T. Dumble." (Harris, 1919, p. 3).[70]

Apparently that recommendation, plus his recent experience with the Arkansas Geological Survey, put Harris in Texas sometime in 1892 and part of 1893, ". . . as Tertiary paleontologist to the Geological [and Mineral] Survey of Texas during the years 1892 and 1893, . . ." (Harris, 1895a). As no letters have been located from Clara to him during this period of time, it is not known whether his new wife and daughter accompanied him to Texas or not, but most likely, as in previous separations, Clara and Rebecca returned to her home at Harmony, New York while he worked in Texas.

Given his successful work in Arkansas with Branner both in 1888 and in 1892, it would been logical for him to join the Arkansas Survey instead of the one in Texas. Funding problems, however, were plaguing Branner as well as his counterparts in Washington, but for a different reason:

> "Since the main reason for the re-establishment of the survey [in 1887] was to ascertain the potential for gold and silver in western Arkansas, it was essential that this be one of the investigations conducted. Dr. Branner's staff made an evaluation of the gold and silver prospects open at that time and showed that at least in case of the mines then open, there was no validity in claims being made about gold possibilities. This so irritated some people in the State that funding for the geological Survey was withdrawn, not to be re-established until 1923!" [Emphasis in the original.] (Anonymous, 1988, p. 21.).

They were angry for him "standing in the way" of progress and Branner was publicly castigated by members of the legislature. One angry mob of potential speculators and miners actually burned him in effigy (Brice, 1989). Thus, Harris embarked on a series of professional situations where his fate and the fate of his work would be in the hands of politicians.

Harris arrived in Texas late in 1892 and stayed until early 1893. While there, he was able to make comparisons between the fossils from Texas with ones in the collections in Washington, D.C. He continued to make more collections of his own as he travelled the coast on his trips between Texas and Washington. He found that the Paleocene Midwayan Stage extended well into Texas, as did the Eocene Lower Claibornian which had been described previously from Arkansas and Alabama (Palmer, 1953c). These discoveries, although seemingly minor today, were important pieces of stratigraphic information for unraveling the biological and geological history of the Coastal Plain, a study which would occupy Harris for the remainder of his career.

He returned to Texas again during the winter term of 1926–27, toward the end of his teaching career, but this time he went as a visiting professor at the University of Texas, invited there by his former student, Professor Francis L. Whitney (Palmer 1953c).[71]

In April 1891, a well was drilled near Galveston to a depth of just over 3000 feet and Harris had an opportunity to examine the samples from this deep hole. This work was briefly mentioned in the 4th Annual Report of the Texas Survey for 1892 (Harris, 1893b) and in a joint paper with E. T. Dumble (Dumble and Harris, 1893). Harris eventually produced a 400 page manuscript on the Tertiary geology and paleontology of Texas. The manuscript was clearly state-of-the-art for its time, but Harris experienced great difficulties getting it into print. According to Johansen (1988), at this point the entire Texas survey lost its funding. Apparently it was:

> ". . . the subject of a fight [no reason given] in the twenty-third Legislature and was denied funding by the governor in 1893." (Johansen, 1988, p. 410).

This condition of no funding continued until this Survey's official termination in 1901 when a new organization, the University of Texas Mineral Survey, was created. Harris' monograph, however, was not part of the new Survey's publishing agenda.

In a later publication of parts of the Texas monograph by the Academy of Natural Sciences of Philadelphia, Harris described the situation:

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[69] The full name at that time was the Geological and Mineral Survey of Texas (Johansen, 1988).

[70] In the Harris Archives is a small handwritten note, "as told oraly [*sic*] by Harris to Palmer, 8/46" which states, "Walcott suggested Harris for Texas Survey . . ." HA-PRI, Ithaca, NY.

[71] Annual Report by Heinrich Ries for 1926–27 states that Harris was on leave from January to March, 1927 to give lectures in Texas. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

> "While employed as Tertiary paleontologist to the Geological Survey of Texas during the years 1892 and 1893, the writer prepared a large monograph on the Tertiary mollusca of the State with the intention of publishing it in the 5th Annual Report of that Survey. For want of funds the printing of this report has been indefinitely postponed and accordingly the following facts and descriptions of new species, taken from the monograph in question, have here found an appropriate place for publication." (Harris, 1895a, p.45).

The State Geologist of Texas, E. T. Dumble, included some of the stratigraphic data from Harris' work in an 1893 paper in the *Journal of Geology* in which he stated that the report was based:

> ". . . partly on that of other members of the survey, and the paleontological studies of Cope, Harris, and Cragin, the details of which have been given in previous publications or will appear in the Fifth Annual Report of the Geological Survey." (Dumble, 1894, p. 549).

Later, in 1895, Harris published another piece of the monograph as No. 3 of volume 1 of the *Bulletins of American Paleontology*, "Neocene mollusca of Texas or fossils from the Deep Well at Galveston" (Harris, 1895c). Most of the manuscript, however, was never published. In 1937, Harris described the situation with these words:

> "Forty-four years ago the writer completed a monograph on the Tertiary Mollusca of Texas for the Geological Survey of that State. The plates illustrating the fauna were engraved and a few proof copies struck off; but the finances of the Survey seemed at that time scarcely ample to warrant immediate publication. The Survey was soon discontinued. Some of the new or otherwise interesting material of this monograph was excerpted and published in the Proceedings of the Philadelphia Academy (Nat. Sci.) for 1895, but the bulk of the material has remained unpublished to this day." (Harris, 1937a, Foreword dated April 10th, p. 3).

What was lost to the world of paleontology can be seen from a description Harris (1895c) gave of the table of contents of that typewritten monograph:

> "*Preliminary Remarks*, pp. 1–5.
>
> Part 1. *Brief review of the literature on the Tertiary mollusca of Texas*, pp. 6–21.
>
> Part 2. *Eocene mollusca of Texas*, pp. 22–352.—The name, author, synonymy, original description, additional remarks, all known localities for each species in Texas, important localities in other States, geological range, and where the type specimen may now be found.
>
> Addenda to Part 2. *New or interesting Eocene mollusca from other States*, pp. 353–357,
>
> Part 3. *Neocene mollusca of Texas, or Fossils from the Galveston deep well*, pp. 358–397.—The name, etc. as in Pt. 2, and the range in depth of each species.
>
> Part 4. *Definition and correlation of the marine Tertiary deposits of Texas*, pp. 398–409.—Section I. Review of the works and opinions of earlier writers. Sec. 2. Conclusions drawn from the present paleontological study.
>
> "The last mentioned part is followed by (1) a detail [sic] account of all the localities or stations whence the Tertiary fossils were obtained, (2) a table showing at a glance the geographical distribution of the Eocene molluscan species in Texas and their geological range in this State and others farther east, (3) a table showing the bathymetric distribution of the Galveston well fossils, pp. 410–434, and (4) 36 large octavo plates illustrating the species mentioned or described in Parts 2 and 3.
>
> "The article published by the Academy [of Natural Sciences of Philadelphia] contained the description of the new species of Part 2 and the figures belonging thereto; the majority of that part, and which alone is of present stratigraphic value, still remains in manuscript.
>
> "This Bulletin [Number 3] is practically a condensation of Part 3. It seems advisable that this unique material should no longer remain unpublished, for up to the date no other marine Neocene fossils are known from the Gulf slope west of Mississippi." (Harris, 1895c, p. 85).

Unfortunately, it appears that most of this manuscript no longer exists; only about 100 pages of the fossil descriptions survive in the Harris Archives at PRI.

Harris must not have spent all of 1893 in Texas, however, for it was in the spring of that year that he embarked on his first private publishing venture, working with a printing company in Washington, D. C. He must have spent at least some time in Washington to oversee the final stages of this project.

As he delved more deeply into the world of Tertiary fossils, Harris noted a scarcity of original copies of the early works describing these fossils, especially the works of Timothy Abbott Conrad[72] which had been published in the 1830s. In a footnote on page 5 of his reprint, Harris described the location of the 16 known copies in 1893. Especially bothersome was that their rarity made taking copies of Conrad's publications into the field out of the question. Harris therefore set out to remedy the situation, at least partially, by arranging a reprint of Conrad's *Fossil Shells of the Tertiary Formations of North America* (Conrad, 1832, 1833; Harris, 1893c). Harris stated the reason for undertaking such a venture in the Introduction to his reprint:

> "He who would become versed in the marine Tertiary geology and paleontology of this country must first of all have a thorough understanding of Conrad's FOSSIL SHELLS OF THE TERTIARY FORMATIONS OF

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[72] Timothy Abbott Conrad (1803–1877) was a famous pioneer paleontologist who is remembered especially for his work with Cenozoic fossils. See Wheeler (1935) for details of Conrad's life and work.

> NORTH AMERICA: it marks the beginning of systematic research into this period of our continent's history." (Harris, 1893c, p. 5).

Harris had 225 copies of the text and 200 copies of the illustrations re-printed at his own expense; he then sold copies, both in the U.S. and abroad, to recover the costs. The printing was done in April, 1893, and until November of that year the cost was $3.00, postpaid in the U.S., but after that date, the price was $3.50. This small advertisement was put in early editions of the *Bulletins of American Paleontology*:

> "A few copies of our reprint of Conrad's *Fossil Shells of the Tertiary Formations* still remain unsold. **Price:** $3.50.
> Address
> Gilbert D. Harris, Ithaca, N.Y.
> or,
> Wm. Wesley & Son, 28 Essex Street, Strand, London, England"[73]

He finally sold the last of these in the 1930s (Palmer, 1963). PRI re-issued this Conrad volume in 1963; it was still available in 1995.

Harris was not alone in reprinting Conrad's work. Also in 1893, Dall arranged to reprint some of Conrad's works (Dall 1893a, b). Harris published a short paper about Dall's work[74] with Conrad's publications (Harris, 1893d) pointing out some errors Dall had made in getting the proper publication dates for Conrad's works.

At the end of this small article Harris wrote: "Washington, D.C. February 25, 1893", and it starts with the words, "Upon my return to Washington from a sojourn in Texas, . . ."; thus by the end of February of 1893 he was back in Washington, D. C.[75] According to Palmer (1953c), Harris had returned to the Smithsonian to work on his own fossils.

But Harris' life was about to take another major twist. While he was exploring the rocks of southern Texas, his Alma Mater had experienced some major changes in its geology faculty. Henry S. Williams, who had studied at Yale and had been Harris' professor, had been asked by James Dana to return to Yale as his successor. This left no one at Cornell in paleontology, for Ralph S. Tarr, who came to the department in January 1892, was a physical geographer. To be sure, Tarr had worked with Permian rocks (Tarr, 1892) while employed with the same Geological and Mineral Survey of Texas as Harris, but paleontology was not his favorite part of geology. To remedy this situation, Cornell's President, Jacob Gould Schurman, approached Harris about joining the faculty there (Brice, 1989).

Based upon a letter from J.C. Branner to Harris a few months after he came to Cornell, it seems Schurman considered several other people, in addition to Harris, for the position. Interestingly enough, Harris gave Schurman a strong recommendation for one of the other candidates, Charles Prosser, who had been H. S. Williams' assistant when Harris did the extra year of graduate study before going to Arkansas the first time:

> "My dear Harris:
>
> "I am glad to see that the geol. dept. at Cornell is 'getting a move on.' . . .
>
> "As for the Texas work—what can you expect? In Ark. they block my work at every nook and corner, and in the meantime howl because the reports are not out. They make me sick." . . .
>
> "In order to set Prosser right in regard to your appointment at Cornell, I wrote him since I came back this fall telling him that I knew about your efforts in his behalf. When he replied it was evident that he didn't believe all I told him, altho [*sic*] he said he wished you all success and that sort of thing. He doesn't know how you stood up for him, and he won't believe it for my telling him about it."[76]

No doubt Harris received recommendations from J. C. Branner and others, and eventually he was offered the position as instructor ($1,000 per year) with possible promotion to assistant professor ($1,400–1,800 per year); this even though he had no teaching experience. Apparently Harris replied to Schurman's first offer with several questions and possibly some requests, one of which apparently was for an appointment as a Professor, not Instructor, of Paleontology. Schurman had these responses:

> "It is not likely, however, that we shall either now or in the near future appoint a full professor for this subject [paleontology], as we are desirous of giving greater prominence to geology proper."[77]

and 10 days later:

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[73] Printed inside the back cover of *Bulletins of American Paleontology*, No. 1 (May), 1895.

[74] Dall, William Healey, Determination of dates of publication of Conrad's *Fossils of the Tertiary Formation and Medial Tertiary*: Read before the Philosophical Society, November 12, 1892. This information on Dall's paper came from Harris, 1893d.

[75] An interesting note about his paper on Dall's Conrad material is that on all reprint copies found at PRI, someone, probably Harris, modified a word in the title, from "Collection" to "Collation." There must have been a typographical error in the printed title.

[76] Letter from J. C. Branner to Gilbert D. Harris, December 2, 1894. At this time Harris and his family were living at 60 Eddy Street. HA-PRI, Ithaca, NY.

[77] Jacob G. Schurman to Gilbert D. Harris, November 15, 1893. Jacob Gould Schurman Papers 3/4/6; Reel 8 (vol. 2, p. 43). RMC-KL, Cornell.

> "Instead of getting a professor of general geology, I think we are more likely to get a number of young men who will specialize as instructors or assistant professors in paleontology, mineralogy, petrography, physical geography and other divisions of the general subject. At present I do not know who the teachers will be in any of these branches; but I had thought of you for paleontology. Your letter, however, leaves me in uncertainty whether you desire such a position."[78]

A small handwritten note in the Harris Archives indicates that when he was first offered the position at the instructor rank, Harris said no, but he would come at the higher rank.[79] After this, Harris must have given a more positive response to the offer, but he asked for $1500. He indicated, however, that he would come for less money if he received the rank of assistant professor. In December of 1893 Schurman wrote to him:

> "After consultation with the Trustees, I have much pleasure in informing you that we have virtually appointed you assistant professor of Paleontology, for the usual term of three years, at the usual salary of $1400 a year. . . .
>
> "We propose to have three young men as assistant professors in the department. One will take Dynamic Geology and Physical Geography and probably also Economic Geology; the second, Paleontology, and the third, Mineralogy and Petrography. Each of these men is to be independent of the others; . . . your position would be that of assistant professor of Paleontology."[80]

The formal appointment by the Board of Trustees came in January 1894:

> "I congratulate you on the appointment; and am heartily glad that you are to continue at your Alma Mater the work so admirably done by Professor H. S. Williams."[81]

And so, by January 1894, Harris had secured an appointment to Cornell where he was to stay until his retirement in 1934 (Plate 2). Yet from the beginning a cloud was to be over his head, for one phrase in Schurman's letter quoted previously, "Each of these men is to be independent of the others; . . .", was to echo through McGraw Hall for well over 70 years. With that phrase, Schurman, perhaps unknowingly, created three separate departments where there had been one, and each of the three men interpreted Schurman's word "independent" as literally as possible.

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[78] Jacob G. Schurman to Gilbert D. Harris, November 25, 1893. Jacob Gould Schurman Papers 3/4/6; Reel 8 (vol. 2, p. 82). RMC-KL, Cornell.

[79] Handwritten note, "as told oraly [*sic*] by Harris to Palmer, 8/46." HA-PRI, Ithaca, NY.

[80] Jacob G. Schurman to Gilbert D. Harris, December 13, 1893. Jacob Gould Schurman Papers 3/4/6; Reel 8 (vol. 2, p. 122). RMC-KL, Cornell.

[81] Jacob G. Schurman to Gilbert D. Harris, January 13, 1894. Jacob Gould Schurman Papers 3/4/6; Reel 8 (vol. 2, p. 179). RMC-KL, Cornell.

CHAPTER 3. RETURN TO CORNELL

From its beginnings in 1868 under the leadership of Charles Frederic Hartt, paleontology was the major emphasis in geology at Cornell. By 1874, the original name, School of Geology, was changed to School of Geology and Paleontology, reflecting this emphasis. With Hartt's departure for Brazil in 1874, followed a year later by his assistant, Orville A. Derby, paleontology was given less emphasis in the department until Henry Shaler Williams joined the faculty in 1879. Williams once again put paleontology and stratigraphy into the forefront of research activities and teaching at Cornell. Even after the addition of mineralogy in 1887 when the name became School of Geology, Paleontology, and Mineralogy, paleontology was still a major part of the curriculum.

Upon the retirement of James Dana from Yale in 1892, H. S. Williams left Cornell to replace him and paleontology was de-emphasized once again, a condition that continued for several years because the Department had no paleontologist. Williams gave his reasons for leaving in a letter to C. K. Adams, President of Cornell:

> "I am requested to accept the Professorship of Geology in Yale college to succeed Professor J. D. Dana. This call from my 'Alma Mater,' accompanied with a personal invitation from Professor Dana, comes with a force difficult to resist."[1]

At about the time Williams was contemplating his departure, R. S. Tarr was hired[2] as a replacement for

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[1] Letter from H. S. Williams to C. K. Adams, March 23, 1892. Reproduced as part of the Cornell University Board of Trustees meeting minutes, June 15, 1892.

[2] Tarr was appointed Assistant Professor of Geology and Mineralogy for the balance of the 1891–92 academic year at a salary of $1000. There is no mention of his being placed in charge of the department; Cornell University Board of Trustees meeting minutes,

J. Francis Williams[3] (no relation to H. S. Williams) a young petrographer who, in 1891 at the age of 29, died expectedly from complications following an illness contracted while doing field work in Arkansas. But Tarr was only an acting assistant professor on an annual contract. While he was a capable scientist, Tarr was not a lover of fossils, nor was he a mineralogist and he made repeated requests to the administration for additional faculty. But nothing transpired until 1894 when two new assistant professors arrived; Adam Capen Gill to teach mineralogy and Harris to teach paleontology. There is no record that Tarr and Harris knew each other, except perhaps by reputation, even though they had worked with the Texas Survey at the same time. Harris was a member of one field party and Tarr was with another.

When these two new assistant professors were hired, Tarr's status changed from temporary to regular[4]. There is, however, no official record that Tarr was consulted about either of the two appointments although he had been acting as the unofficial head of the department since H. S. Williams left to go to Yale. In fact, one source suggests that Tarr actually had been appointed department head:

> ". . . [in 1891–92] Ralph Stockman Tarr was elected assistant professor of geology and *placed in charge of the department*, . . ." [Emphasis added.] (Hewett, 1905, v. II, p. 235).

No official record of this has been found.

But Tarr's feelings can be determined from a hand written note found in the margin of a newspaper article announcing the arrival of the two new faculty members in which he indicated that these appointments will divide the department into three parts (Brice, 1989, p. 75), which is exactly what happened. For the 1894–95 academic year, the university budget lists three separate line items for the department, Dynamical Geology, Geological Mineralogy, and Paleontology (Brice, 1989, p.75). Thus, the department that Harris joined in 1894 was vastly different from the one in which he had studied eight years earlier.

Harris was mindful of the limitations of his experience in world geology, especially in the nature of the European type localities for the Tertiary, *i.e.*, the locations where the particular stratigraphic units were first described. So he had important items on his agenda before he took up his duties at Cornell: to see and study those original localities, to study museum collections, and obtain specimens for his own collection (Palmer 1953c).[5] This trip not only broadened his knowledge of European stratigraphy, but it served to introduce him to the paleontologists on that side of the Atlantic, and he was elected to membership in the *Société Géologique de France* (Palmer, 1953c). According to Harris' memorial in the Cornell Faculty Necrology (Herrick *et al.*, 1953), such memberships were not awarded lightly; the person had to be worthy of the honor, especially someone from the United States.

As he knew Williams' specialty was the Paleozoic and that Cornell's collection held little Tertiary material, Harris sought to increase the collection of Tertiary fossils in the department, and asked President Schurman for support. Schurman expressed his pleasure that Dall was donating a:

> ". . . duplicate set of Tertiary fossils . . . [and Schurman was providing] . . . $25 or so to pay for the selection of them; . . ."[6]

It was also at about this time that Harris established a working relationship with James Dwight Dana at Yale. Just what prompted this connection or who initiated it is unknown, but it probably developed because of Harris' work with Dall and the U.S.G.S Neocene Correlation Project published in 1892. In any case, some time in 1893 or 1894, Harris worked with Dana on the Tertiary section of a new edition of Dana's enormously popular and influential *Manual of Geology* (Dana, 1895). Although Palmer (1953c) indicated that Harris traveled to New Haven to work in Dana's office, a letter from Dana indicates that they used the mails for communication as well. Dana comments on the work Harris had done:

> "I enclose herewith the plates from old number of the Proceedings of the Acad. N. Sci. Philad. which you very kindly sent me for the benefit of my book. The publishers having recently returned them to me.
>
> "The printing of the index now will bring the book to an end.

December 15, 1891. He was reappointed Assistant Professor of Geology for 1892–93, salary $1400; Trustee minutes, August 18, 1892; and Assistant professor of Geology and Paleontology for 1893–94, salary $1700; Trustee minutes, May 9, 1893.

[3] J. F. Williams was hired on June 9, 1891 and died on November 17, 1891; Cornell University Board of Trustees meeting minutes, June 9, 1891.

[4] He received a three year contract as an Assistant Professor of Dynamic Geology and Physical Geography, salary $1700; Cornell University Board of Trustees meeting minutes, January 9, 1894.

[5] In the Foreword to a later publication, Harris said "After collecting fossils in France and England in 1894. . ." (Harris, 1937a, p. 3)

[6] Jacob G. Schurman to Gilbert D. Harris, February 8, 1864. Jacob Gould Schurman Papers; 3/4/6; Reel 8 (vol.2, p. 245). RMC-KL, Cornell.

> "I thank you again for all your kindness and greatly valued favor.
>
> "You noticed that in one point I did not follow your ms—that is in the use of the word epoch in connection with the subdivisions other than those of the Atlantic and Mexican Gulf borders. My reason was that the *time for continent* is covered by one series of epochs, or should be: after one series is recognized and established by *fossils* for without fossils, a series of beds cannot represent any time division satisfactorily. The great purpose of study is the correlation of the beds of other regions with those so recognized, in order to give unity to the history. Several sets of epochs formulate this purpose. You know that Prof. W. B. Clarke named the N.J. Tertiary subdivisions as epochs; and made a hodge-poge of the matter, as the 1st and 2nd [illegible] belong together, and perhaps also the Clay Marls below; and the 3d [illegible] has not fossils enough to fix its equivalency. The Clay marl stratum is worse off as to fossils.
>
> "I have written this that you may have my reason for the divergence from you." [emphasis in original][7]

As Dana died in April, 1895, this edition was his final work (Williams, H. S., 1895). According to Williams' memorial for Dana, he was confined to New Haven during the last few months of his life while he was working on this fourth edition, so if they were to work together, in person, then Harris would have been the one to do the traveling.

In the preface, Dana acknowledged Harris' assistance:

> ". . . and the Tertiary, as regards the Invertebrates, to PROFESSOR G. D. HARRIS. . . . and that with regard to the marine Tertiary of the country was chiefly written for its place by PROFESSOR HARRIS." [Capitalization in the original.] (Dana, 1895, p. 4).

The Tertiary section in Dana's book runs from page 879 to 939, and Harris not only assisted with the writing, but he also drew several fossil plates found on pages 896 and 897, and described many species found in the fossil lists for the Eocene.

This collaboration must have been quite a boost for Harris, for the fact that he was able to work with James Dana, arguably the preeminent geologist of his time, certainly indicated that he had already made a reputation as a Tertiary paleontologist. The *Manual* was a very important book, described by Williams has having:

> ". . . done more to unify and codify American geology than any other work, and until very recent years, if we may judge from their literary quotations, foreign geologists have made Dana's *Manual* their chief source of information regarding the geology of America. . . . [This last edition provides] a complete account of the state of the science at the time of its publication." (Williams, H. S., 1895, p. 620).

PRINTER AND PUBLISHER

That first year at Cornell, 1894–95, was certainly a busy one for Harris, for along with the trip to Europe and the work for Dana, Harris was preparing for a new career as a teacher. He also launched what would become a major preoccupation for the rest of his life. Harris had become quite frustrated in his dealing with government agencies over publication delays—or in the case of his Yorktown manuscript and his Texas monograph, lack of publication—of his own work in paleontology. Encouraged by his earlier success with the Conrad reprint venture, Harris became convinced that there was a need for a completely new, scientific journal devoted exclusively to paleontology. With that in mind, on May 25th, 1895, Harris published issue one, volume one of the *Bulletins of American Paleontology*. His new journal was devoted exclusively to stratigraphy and paleontology, and Harris was willing to publish papers that were quite long, often encompassing a single issue, which was a novel idea for scientific journals at the time.[8] In 1995 the *Bulletins* reached the 100th year of publication, making it the oldest journal in the western hemisphere devoted exclusively to paleontology[9], and it is among the three or four oldest such publications in the world.

Harris not only founded and published the *Bulletins*, but he printed them on his own platen press in the third-floor "tower room," off the gallery in the central section of McGraw Hall at Cornell. The first issue of the *Bulletins* appeared under the imprint: "Harris and Stoneman" (using his wife's maiden name); "Harris Company" appeared on issue number four. Over time the imprint became "The Harris Company," which remained on all issues until Volume 20 in 1932, when it was replaced by the imprint of the Paleontological Research Institution (PRI), the organization Harris founded that same year. With its founding, PRI became the publisher of the *Bulletins*, a role that continues to the present day. It was well Harris had somewhere else for his printing operation because the vibration was causing some problems in McGraw Hall and the University wanted it moved:

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[7] Letter from James Dwight Dana to Gilbert D. Harris, November 26, 1894. No envelope accompanies the letter, so Harris' location at the time Dana wrote him is unknown, but it is assumed he was in Ithaca. HA-PRI, Ithaca, NY.

[8] The journal today continues Harris' innovative policy of having a single issue devoted to one paper when appropriate.

[9] The next oldest in the U.S. is the *Journal of Paleontology*. According to the "NOTICE TO MICROPALEONTOLOGISTS" signed by J. J. Galloway, the first editor, and dated December 14, 1926, "Plans are now nearly complete for beginning the publication of the *Journal of Paleontology*, which was founded by the Section of Paleontology of the American Association of Petroleum Geologists." Actual publication began in 1927. HA-PRI, Ithaca, NY.

> "The 'powers' also feel that your printing press in the tower room on the third floor is an unsafe load, and would appreciate it if you can move it to some other place. Mr. Van Blarcom says that they will move it to any place that you may designate without expense to yourself."[10]

On the back cover of Volume 1, Number 1, dated May 25, 1895, Harris wrote:

> "ANNOUNCEMENT
>
> These Bulletins will appear when suitable material is prepared for them and not necessarily at regular intervals. They will not represent work done by one person or institution[11] but will be of a more general nature subject to acceptable contributions from all paleontological workers. They will, we believe, serve as a receptacle for articles too technical or long for the ordinary monthly periodicals and too important to admit a delay from one to an indefinite number of years in a government printing office. Moreover, the desirability of amassing articles relating to one branch of knowledge in one publication, must be evident to all."

This announcement reveals Harris's experiences with long publication delays in government printing offices from his days with the U.S.G.S. and the Geological Surveys of Arkansas and Texas. He alluded to the problem again in Number 3 of Volume 1 (Harris, 1895c), in the paper about the Galveston Deep Well fossils, and he summarized the contents of his large Tertiary fossil monograph that had been "in press" for several years, but at that time had still not appeared.[12]

Also, the organization of his own publishing company gave him the ability to reprint classic works in paleontology as he had done earlier with the Conrad reprint. In his reprint of the paleontological writings of Thomas Say[13] Harris explained why he felt compelled to do these reprints:

> "For several years we have been endeavoring to decide upon the most feasible plan for rendering the paleontological literature of America, especially that from 1800 to 1860, more accessible to young students. . . . All digests, adaptations or condensations of works dealing with the systematic side of natural history have seemed but delusions, and fraught with grave dangers; for, what two persons would cull out the same passages as worthy of going into a digest of an author's writings!—the author alone knew just what he wanted to say and how to say it.
>
> "Surely, no scholar will ever rest contented with an abridged form of any author's works; he must have the real thing. But if the real thing is beyond his means and there are no magnificent libraries to which he had access, what is he to do? There seems to be but one really satisfactory solution to the difficulty, *viz.*, a republication of each author's work, exactly as he wrote and punctuated it, word for word, line for line, page for page, and plate for plate, regardless of the publication in which it first appeared.
>
> ". . . Doubtless some will believe that it is means thrown away to republish these short and seemingly unimportant articles [by Say]. Yet we believe such not to be the case. More than once have our European co-workers overlooked Say's original description of *Exogyra* and credited the genus to Sowerby, too often has Say's work on 'Crinoidea' been forgotten. . . .
>
> ". . . The humble task of republication . . . can point out the way in which the study of paleontology can be forwarded . . . by making its literature accessible, at a very modest cost, in a most convenient form . . ." (Harris, 1896b, p. 273–274).

In 1921, Harris brought out a reprint of the paleontological writings of Robert J. L. Guppy (Harris, 1921).[14] This tradition was continued by Harris' successor as editor of the *Bulletins*, Katherine V. W. Palmer.

Originally the cost of the *Bulletins* was one dollar per one hundred pages, "strictly in advance." Harris must have tried to attract some advertising as well, for inside the front cover of issue Number one is an announcement for *The Nautilus*, a journal published by the Academy of Natural Sciences in Philadelphia. As he had recently published a paper in their proceedings (Harris, 1895a), however, he might not have charged for the space. The notice did not appear in the second issue.

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[10] Heinrich Ries to G. D. Harris, October 15, 1934. Heinrich Ries Papers, 15/15/691, Box 1, File 1-24. RMC-KL, Cornell.

[11] These remarks probably concern James Dana's *American Journal of Science*, published at Yale University, and the *Journal of Geology*, published at the University of Chicago.

[12] As mentioned earlier, parts of the Texas manuscript were published by both Harris (1895a) and the Texas State Geologist, Edwin T. Dumble (1894), but most of it was never published. A small portion of the original manuscript is in the Harris Archives at PRI.

[13] Thomas Say (1787–1834) was a self-taught naturalist who was a charter member of the Academy of Natural Sciences of Philadelphia. He was a friend and co-worker of William Maclure (who produced one of the earliest geologic maps of the U.S.), and in 1816 he wrote the first paper by an American about American shells. Say did major works in conchology (6 volumes) and entomology (3 volumes). (*Dictionary of Scientific Biography*, v. XIV, p. 132–134).

[14] Robert John Lechmere Guppy (b. London 1836-d. Port of Spain 1916), trained as a civil engineer, settled in Trinidad in 1859 after traveling in Australia (Tasmania) and New Zealand. He wrote almost 100 papers on the geology of Trinidad and the West Indies (Guppy, 1907). Shortly before his death, Carlotta Maury, a former Harris student, mounted her expedition to San Domingo in 1916. In a letter to Harris, Guppy indicated he was hoping to hear something of the "Maury Expedition." R. J. Lechmere Guppy to Gilbert D. Harris, April 18, 1916. HA-PRI, Ithaca, NY.

Irregular publication was certainly the case with the early issues of the *Bulletins*; the five issues of Volume 1 appeared between May 25, 1895, and December 7, 1896. Being his own publisher, furthermore, reduced the possibility that unfavorable comments from a peer review would stop or delay publication—and in the early volumes, Harris' own writings predominate (Harris, 1895b,c; 1896a). He did, however, make an effort to attract other authors, for in June of 1896, *Science* carried a small note[15]:

> "A prize of $50 is offered by the editor of the Bulletins of American Paleontology, Prof. G. D. Harris, of Cornell University, for a monograph suitable for publication in the bulletins; it must be presented before May 1, 1897." (June 19, 1896)

At some point, another Cornell faculty member took a leaf from the Harris book and formed a printing company. In the Harris Archives is a large undated envelop with an advertisement on it for a publication from "The Comstock Publishing Company, Ithaca, New York." The publication is "The Moth and Butterfly Outlines", and this company was created by John H. Comstock, Professor of Entomology, who was a contemporary of Harris' (but no relation to the Comstock who was in the Geology Department in the 1870s). Perhaps Comstock saw "The Harris Company" success and attempted to develop a similar enterprise, but this is the only reference I have ever seen to 'The Comstock Company."

There was also an advantage for students that Harris owned his own scientific journal. His major philosophy of teaching was to allow students to learn by doing actual research, and the final product of such activity was (and is) to put the work before colleagues in the field by the publication of the results. Edward M. Kindle, a student at Cornell during Harris' second year of teaching, was the first to benefit from this arrangement. His Master's Degree thesis, a study of Devonian stratigraphy and paleontology in the Ithaca area, was published in the *Bulletins* (Kindle, 1896), the first of many student theses to be printed in a Harris publication (*e.g.*, Sheldon, 1916; Hodson, F., 1926; Weisbord, 1926; Schoonover, 1941). A measure of the quality of this first student author can be seen in the fact that Kindle was a geologically multi-talented student, for the same year in which he published his work on the Devonian strata and fossils of the Ithaca area, he went to Greenland as a member of Professor Tarr's 1896 expedition to study glacial activity there (Brice, 1989).

Later, when Harris had his field camp in the Helderbergs near Albany, New York, other students were also able to see the result of their labors in print. Herdman F. Cleland (later a professor at Williams College) discovered a previously undescribed fossil fauna in the limestones of the Mohawk Valley, and this work was published in the *Bulletins* (Cleland, 1900, 1903), The 1900 field camp was the first of several for Percy E. Raymond (who the following year was a graduate student at Yale and later had a distinguished career at Harvard), and he, too, published on material gathered while attending Harris' field camp (Raymond, 1902, 1903). Harris had high esteem for Raymond: "Mr Raymond, by natural instinct a geologist before he ever came to Cornell."[16]

Apparently not everyone at Cornell appreciated Harris being able to publish student work in his journal, and the objections must have reached the Cornell administration. In 1913, Harris responded to Ernest Merritt, Dean of the Graduate School:

> ". . . in general it seems to me, that any Professor is in a way more or less responsible financially for the publication of this [*sic*] thesis by students under his direction. . . . Some I have heard of, have been published by publications having considerable means at their disposal, would cost the student not less than $1500. Any such drain on the ordinary student's finance [for] the cost of a very unremunerative career of study, would seem to me disastrous. . . . Naturally, so far as my own department is concerned, I look out after the publication myself for the subjects are usually Paleontological and can be made to fit in as one of my Bulletins of American Paleontology. Naturally many of us are wishing that our University could have a press of its own wherein things might be published, serving thus as a means of exchange and as it were a legitimate means of advertising our research work. However, naturally, I am getting along without such University support in a very satisfactory manner."[17]

The perceived lack of support by the University, alluded to in the last sentence, was to continue to trouble Harris for many years.

By 1916, Harris had become dissatisfied with the coverage and the small (octavo) size of the *Bulletins* and felt the need for another series of larger size. He therefore began *Palæontographica Americana*, a quarto sized monographic series, 21 years after he began the *Bulletins*.[18] This larger-format publication was to emphasize more detailed, systematic papers on invertebrate paleontology. Most importantly, given the larger format, the illustrations could be larger. With his new journal, Harris followed the European tradition for publications of this type in both name and size, *e.g., Palæontographica Italica* (1895) and *Palæontographica* (German, 1851).

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[15] A similar notice was printed in the *American Journal of Science*, 4th Series, v. 2, pp. 85–86.

[16] *Annual Report to the President of Cornell University of the Department of Paleontology and Stratigraphic Geology*, May 15, 1901, by Gilbert D. Harris, p. 5. HA-PRI, Ithaca, NY.

[17] Unsigned carbon copy, Gilbert D. Harris to Ernest Merritt, December 8, 1913. HA-PRI, Ithaca, NY.

Harris' introduction to the first issue of *Palæontographica Americana* also gives a rare insight into his views of both the role of paleontological research and publication in studies of organic evolution, and the place he believed his publications would assume in the history of American paleontology:

> "Several years ago we commenced a series of papers in 'Bulletins of American Paleontology,' dealing with the molluscan remains in the various horizons of our southern Tertiaries. In these the subject matter is treated stratigraphically; in other words, the Midway stage was first taken up, then the Lignitic, and now the Claiborne is in press.[19] Other papers dealing with special localities or horizons have also been published. In future numbers we hope to discuss all important Tertiary horizons stratigraphically. This seems the natural way for all investigation of this preliminary nature. Witness for example Hall's works on the paleontology of New York as well as the paleontological matter included in our various state survey reports. Such papers if printed in small octavo form are convenient for field use as well as laboratory study.
>
> "But as years pass by and the faunas of the various horizons are better understood, and vast amounts of material collect in our museums, there comes a time when a purely biologic phase of investigation may be advantageously undertaken. Note for example the more recent works of Clarke and Ruedemann of the New York survey. This calls for a larger sized publication, admitting plates of sufficient dimensions to contain for comparison representatives of many closely allied types of life. And, the large size page will be found not inconvenient in laboratory and museum where desks and tables are at hand; in the field, a work arranged biologically would scarcely ever be called for. Accordingly, this new work has been begun to receive such papers on invertebrate paleontology as are arranged systematically, papers that will be of direct assistance to students of biologic evolution.
>
> "The first of these papers, unpretentious and seemingly easy of preparation, has cost the author a vast amount of study here and elsewhere to make sure that no serious omissions of specific or varietal forms have been made either in the text or plates, and that the figures and text indicate clearly the characteristic features of each form discussed.
>
> Paleontology Laboratory G. D. Harris
> Cornell University
> October 30, 1916" (Sheldon, 1916, p. 3)

That first issue was a good example of what Harris was trying to accomplish. For her Ph.D. thesis, Pearl Sheldon did a massive study of bivalve mollusks of the ark family, and her work was chosen for the inaugural issue (Sheldon, 1916).

Shortly after Harris' death in 1952, Katherine V. W. Palmer, in response to an inquiry from someone at Ward's Natural Science Establishment, described Harris' publication efforts:

> "'As to the Bulletins, I am enclosing the most recent list so that you may gain an idea of the scope and number that have been published. You will note that he started them in 1895, printing the publications on his own platen press. This he had up in the tower room on the balcony floor of McGraw Hall. He had a typesetter there who set the copy in monotype. Later, in the middle 20's he got a cylinder press on which he could print a signature of 16 pages. This [cylinder press] he had in the basement of his home at 126 Kelvin Place . . . In 1936–37 when we added the second unit to the building of the Paleontological Research Institution, the two presses were moved to the basement of that unit, where the small press remains [1953]. Prof. Harris printed until 1949. That would have been Bulletin 134.
>
> "'Previous to the founding of the Journal of Paleontology in 1927, the Bulletins of American Paleontology were the only publication in America devoted entirely to paleontology. Prof. Harris founded the Bulletins to print his own publications and to help his students publish their theses and papers. By the means which he used, he could reduce the cost of publication so that this could be done. He started in 1917 [actual date of printing] the quarto series, Palaeontographica Americana, a series for monographs of special subjects. Since there were similar series in England, Germany and Italy, this is the series in America of the same standard. This naturally has not had as many numbers published. We have now [1953] in press No. 25, which will be a monograph on *Venericardia*.'" (Anonymous, 1953, p. 49).

The Paleontological Research Institution continues to publish both journals.

Harris had a special interest in the illustrations used in paleontological publications. As mentioned above, he had shown talent as an illustrator at an early age and he contributed several illustrations to Dana's *Manual of Geology*; he also made many of the skillfully executed drawings of fossils for the reports on the Arkansas Tertiary in 1894, and for several other folios. Now with his own journal series he had an opportunity to pursue this interest with great vigor and determination. Many drawings of fossil mollusks found in the early volumes of the *Bulletins* were drawn by his hand. Thus, he was not only editor, frequent contributor, publisher, and printer, but the chief illustrator as well. When photographic illustrations replaced ink drawings, Harris perfected methods developed by H. S. Williams for coating fossils with sal ammoniac (ammonium chloride) to bring out details in the photographs. In addition, in his pursuit of clarity for illustrations, Harris experimented with other photographic techniques using glass negatives and copper plates. Palmer (1953a) indicated that he also experimented with collotype engraving for a few issues:

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[18] Although the title page of the first issue carries the year 1916, on the *Errata* page at the end, Harris says the actual date of publication was January 31, 1917.

[19] Harris did this with the following publications: Midway (Paleocene), *Bulletins* No. 4, 1896; the Lignitic (Wilcox, Sabine), *Bulletins*, Nos. 9, 1897, 11, 1899; Claiborne (Lower and Gosport Sand), *Bulletins* No. 13, 1919, and others on this unit, *Bulletins* 32, 1937 (Palmer); and *Bulletins* No. 117, 1946–47 (Harris and Palmer).

> "I believe the word Collotype is used sometimes generically to include most all of the gelatin processes but, as I understand this process is differentiated from the Heliotype largely by the fact that the so-called gelatin skin remains attached to a thick plate glass and is not removed, placed upon pewter, or fixed for a roller in the process of printing."[20]

His demand for the highest possible quality in all illustrations in his journals is a legacy continued by PRI today as they continue to publish both the *Bulletins* and *Palæontographica Americana*. In fact, no better indication of his emphasis on illustrations can be found than in the complete title, which is seldom used, of this second journal: *Palæontographica Americana-Illustrated Contributions to the Invertebrate Paleontology of America*.

TEACHER

As a teacher, Harris is best remembered for his graduate students and their individual research projects. He was less than effective in large classes, for he had a tendency to speak softly and often off to the side rather than toward the class [21]. One former student remembers Harris as a "wonderfully poor" teacher who did not have any set method of instruction, had a poor delivery, and was seldom prepared. It was not uncommon for Harris to arrive for class with the lantern slides he was going to use wet from the developing process.[22] But despite his apparent lack of preparation and poor lecturing style, Harris did reach the undergraduate student and communicated his enthusiasm and his love for geology. John L. Rich remembered his first encounter with Harris with these words:

> "I first came under the influence of Professor Harris in the year 1903–04 when I took his elementary course in Historical Geology and found a slumbering interest in rocks and fossils fanned to a flame."[23]

In advanced classes, however, Harris was more at ease. He and his students would frequently sit around a table full of mollusks and Harris would describe each one; no lecture, as such, just him talking about the fossils.[24] This was in keeping with his feeling that:

> ". . . far away things and mere principals [*sic*] do not appeal to the young mind as near at hand concrete objects and facts."[25]

For advanced students this technique was clearly inspirational. As Kenneth Caster (A.B. '29, M.S. '31, Ph.D. '33), later of the University of Cincinnati, commented many years later, Harris taught "more by precept than rote or formality," and he treated students as (paraphrasing the motto of Sigma Xi, the scientific research honor society) ". . . zealous companions in research" (Caster, 1973). John Rich, also later at the University of Cincinnati, said that Harris' students:

> ". . . remember especially the stimulus which came from his own active pursuit of scientific studies, his strong personal interest in them [the students], and his habit of assigning to them responsibilities which might ordinarily be considered to be beyond the capacities of students in their earlier years."[26]

One measure of his ability as a teacher lies in the success of his students. To date, more of Harris' students have been awarded paleontology's highest honor in the United States, the Paleontological Society Medal, than any other single professor (Schram, 1992). Three of his students have been so honored: Katherine V. W. Palmer (1972) (the first woman awardee), John W. Wells (1974), and Kenneth E. Caster (1976). For Schram, such success was derived directly from the mentor:

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[20] Unsigned carbon copy, Gilbert D. Harris to Paul Bartsch, December 8, 1913. HA-PRI, Ithaca, NY.

[21] Katherine V. W. Palmer, personal communication, July 28, 1982.

[22] Personal communication, John W. Wells, July 15, 1982.

[23] John L. Rich to Axel A. Olsson, February 21, 1953. HA-PRI, Ithaca, NY.

[24] Personal communication, Dr. John W. Wells, July 15, 1982. Wells served as Harris' graduate assistant about one year after he came to Cornell in 1928 (Brice *et al.*, 1995).

[25] Unsigned carbon copy, Gilbert D. Harris to Edward M. Tuttle, May 30, 1913. HA-PRI, Ithaca, NY.

[26] John L. Rich to Axel A. Olsson, February 21, 1953. HA-PRI, Ithaca, NY.

> ". . . when memories were recalled among the paleontological elite it was not of courses or field trips taken, but precepts learned. The learning was by example and direct transfer in a collaborative situation rather than as a teacher down to his students. . . . in his own acceptance speech (1977) Caster said, 'Harris stimulated his students to great endeavor and when a student won his largely intuitive approval he was treated as an equal, whether or not he was mature or experienced enough to merit this equation.'" (Schram, 1992, p. 473).

The closest thing to a teaching philosophy Harris ever committed to paper was included in one of his Annual Reports; it is short, simple, and goes right to the heart of his approach:

> "The main object for which this department exists, is to furnish students with the opportunity of learning geology in the most natural and efficient manner."[27]

As Palmer put it, however, he was not willing to work with just any student, only those who had a deep desire, sense of devotion, and the necessary discipline for the demanding tasks before them:

> "He was determined but kind. He had no interest for the indifferent student but for those who were capable and energetic, he provided opportunity and stimulation to encourage their interest in geological subjects." (Palmer, 1953c, p. 20)

For Harris, the best teaching took place in a field situation because it was in the field that he felt the greatest learning took place:

> "From the lessons of our own experiences, as well as from the lives of others, we are led irresistibly to the conclusion that the most natural way of acquiring a knowledge of the earth is to be associated in Nature's Laboratory—the field—with some experienced person who is carrying on original investigations."[28]

And one of Harris' favorite field locations was Yawger's Woods, near Union Springs, New York, which is one of the oldest known fossil localities in the Devonian rocks of New York (Plate 8). The site was noted by DeWitt Clinton as early as 1810, and it has been a very popular location to study the densely fossiliferous Oriskany Sandstone ever since. Harris would take the students by boat to the northern end of Cayuga Lake and then they would hike the three or four miles to the outcrop. After making their collections and observations, they would have a pleasant lunch among the rocks and then hike back to Union Springs, making various geological stops along the way. At Union Springs they would board the steamer for the return trip to Ithaca. The questions his students had to answer while on these trips are equally appropriate for today's student:

> "6. Are the banks of the Inlet of soft or hard rock? 20. What are bedding-planes? Joints? 32. Note three classes of animals in the Hamilton shale."[29]

In his approach to learning, Harris seemed to echo the methods of Louis Agassiz, who was so influential in the founding of the Department of Geology at Cornell, and Charles Frederic Hartt, the first professor of Geology at Cornell and a former student of Agassiz (Brice, 1989, 1994b). Like Agassiz, Harris's emphasis was not on the mass memorization of facts, but on the clear and careful amassing of knowledge and understanding of the earth by using the facts. Harris communicated to his students his own great love of learning through example and not by lecture. Like Hartt, Harris showed great enthusiasm for other languages (he once took a course in Sanskrit). Harris also was continuing and using the style of paleontological investigation he learned from H. S. Williams, his professor at Cornell. Williams was a strong advocate of very careful and meticulous collecting from every few centimeters of a section, if possible; a technique which requires much patience and time (Cleland, 1918). The importance of patient, careful study was passed along from Williams via Harris to a new generation of students, who in turn have passed this torch to others.

Harris expected his students, graduate and undergraduate alike, to do professional work almost from their first day of class with him. In his 1901 Annual Report to the President, Harris described his approach with these words:

> "This department has always maintained that the highest grade of teaching is not the rule-of-thumb, text book, didactic lecture work so commonly in vogue in schools, colleges and even universities; it consists rather of saying little, but surrounding the student by the atmosphere of the subject, by taking him in partnership, as it were, in the subject, by attempting to cultivate independence of thought in him at the earliest possible date; in other words, make him work along with his instructor, make of him a scholarly investigator and not a mere student. . . .
>
> "The underlying principle of all true University work must be original investigation. . . . The beginning students

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[27] *Annual Report of the Department of Paleontology and Stratigraphic Geology*; 1899–1900, p. 3, by G. D. Harris. HA-PRI, Ithaca, NY.

[28] *Annual Report of the Department of Paleontology and Stratigraphic Geology*; 1899–1900, p. 3, by G. D. Harris. HA-PRI, Ithaca, NY.

[29] Excerpts from: "Excursions for classes. Two free ones on lake and one by rail to Union Springs or Chemung Narrows, Fall of 1903". Printed list of questions students should answer. HA-PRI,Ithaca, NY.

> are taken into the field and shown a little and required to find out a great deal more. The same principle holds good in our lecture room and laboratory."[30]

Collecting fossils on a field trip was only the beginning; the samples had to be carefully cleaned, identified, and labeled. If anything new or unusual resulted from the study, the students were expected to write about it. Harris encouraged them to publish their results, and with the *Bulletins* he was able to publish the best of what they produced. Harris' ability and willingness to publish the work of students was highly unusual among his contemporaries and would be so even today, and it gave his students an early start as original investigators in paleontological research. Those who continued doing research in paleontology knew that Harris would always be willing to read, if not publish, their results. In this way, Harris gained the steadfast loyalty and devotion of his students that endured to the end of his days and beyond:

> "Those . . . who were his students . . . , realize they were guided by a master's hand, . . ." (Olsson, 1954, p. 128).

Arthur C. Veatch, who came to Cornell in 1898 as a transfer student from Indiana University, was one of Harris' most successful students. Although Veatch's work was not strictly in paleontology, he does provide an example of this loyalty and devotion. Although he did not receive a degree from Cornell, he worked with Harris in his field camps and was Harris' Assistant Geologist on the Louisiana Geological Survey at the age of 21; having served on the Indiana University Geologic Survey at age 19. In 1907, Veatch was attached to President Theodore Roosevelt's office as a special commissioner to study mining laws and mineral-land administration in New Zealand and Australia. The result of this work was the development of the Land Classification Board under the U. S. Geological Survey, with Veatch as the chairman. Later, he was involved in the famous Elk Hills case in California that eventually reached the U.S. Supreme Court and resulted in the legal definition of petroleum as a mineral.[31] This was not his first trip to the courtroom for the U. S. government. In 1908, Veatch was involved in a case in Wyoming in which it was shown, for the first time in a court of law, that geological evidence could be used to prove the presence of underground coal beds that were not visible on the surface (Veatch, 1907). He was among the first to use echo-sounding devices to construct bathymetric charts of high accuracy. He worked on a joint two-year project, with the Geological Society of America and the Coast and Geodetic Survey, in which the continental shelf was mapped from Chesapeake Bay to a point one hundred miles east of Cape Cod, an area of more than fifty thousand square miles. The mapping (Veatch and Smith, 1939) indicated an intricate drainage pattern on the continental shelf that Veatch felt was due to former subaerial erosion. A revealing story about Veatch's character is that while doing a traverse in Africa, he extended his line right through a herd of Cape buffalo. He claimed that it would have taken too long to go around, so he went through them (Heroy, 1942). After the swamps of Louisiana, what were a few buffalo? With regard to his work in Louisiana, Harris too remarked about his daring:

> ". . . especially during the early years of reconnaissance when young Veatch's (A. C.) delight in difficult and successful exploits brought in splendid material from hitherto unheard of localities." (Harris, 1919, pp. 3–4).

Veatch, also, published several important papers related to oil exploration, *e.g.*, Evolution of the Congo Basin (1935).

Veatch was, perhaps, the most financially successful of Harris's students. By age 41 he was Director of the Exploration Department of Sinclair Consolidated Oil Corporation and he was always a strong supporter of Harris and his paleontology at Cornell. In 1915, while in London, Veatch sent a check for $1,000 to Cornell to create a fund "by an anonymous donor,"

> "Which fund shall be available as to principal and interest for any purpose or purposes which in the sole discretion of Professor Gilbert D. Harris shall be of assistance to students of geology.
>
> "Payments shall be made from the fund to Professor Harris as and when requested and no accounts shall be required beyond simple receipts from Professor Harris saying that the sum or sums he may request from time to time have been received and that they are to be expended for purposes which in his opinion will be of assistance to a student or students of geology as the case may be.
>
> "If it is not possible for you to accept a gift with these provisions, please return the cheque to me."[32]

In the accompanying letter, Veatch said of Harris:

> "I may perhaps explain that it has been my privilege to

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[30] *Annual Report to the President of Cornell University of the Department of Paleontology and Stratigraphic Geology* by Gilbert D. Harris; May 15, 1901, p. 1,3. HA-PRI, Ithaca, NY.

[31] United States v. Southern Pacific Company *et al.*: Number 179; argued March 5,6, 1919-decided November 17, 1919. Case Adjudged in the Supreme Court of the United States at the October Term 1919. Citation courtesy of Ms. Ann McGee, Librarian, Widner Law School, Harrisburg, Pennsylvania.

[32] Letter from A. C. Veatch to Cornell University Treasurer, October 25, 1915. Copy in HA-PRI, Ithaca, NY.

> attend courses at three [other universities], and at none of these have I known of any man who so fully as Professor Harris had the real training and development of his students at heart or who to so extreme a degree of unselfishness lived only for their good and the advancement of Science. . . .
>
> "I have had many men through my hands coming from all the larger institutions in the United States as well as a number from Europe, and I can unhesitatingly say that no one is able to train real field geologists and investigators as opposed to mere lecturers on geology, as he, because the real University atmosphere, in contradistinction to that characterizing a college or high school, is more fully realized and more thoroughly pervades Professor Harris' laboratory than any other geological laboratory of which I have any knowledge." (Anonymous, 1915a).

This was written about 10 years after he left Cornell to make his way in the world with the skills and knowledge he gained while in the company of his mentor, Professor Harris.

And well he did make his way in the world. Unfortunately Veatch's wife, Caroline Hornbrook (neé Evans), did not share her husband's allegiance to Cornell or to Harris' PRI, and when she died in June, 1985, her estate of approximately $20 million was left to the North American Unitarian Universalist Association.[33] And all this from someone who started by identifying fossils on the fourth floor of McGraw Hall with G. D. Harris, collected samples around the shores of Cayuga Lake and fought mosquitos in the swamps of Louisiana!

WOMEN STUDENTS

Another aspect of Harris's relationship with students that was atypical of his times was his strong encouragement of female students. At a time when women were not encouraged to pursue higher education, or much formal education at all, and were especially discouraged from pursuing science, Harris actively supported their endeavors in paleontology. Years later one of his former students remembered Harris:

> "I went to Cornell for two years after my graduation from Mount Holyoke College, and received my Master's [*sic*] degree. My Master's thesis was under the direction of G. D. Harris, who was the ONLY one in the department who felt kindly toward women. My original idea had been a thesis in Structural Geology under Charles M. Nevin but he flatly refused to have a woman. Altho [*sic*] a few months later, when I had already begun with Harris, he did change his mind." [Emphasis in the original.][34]

Cornell University, as a whole, had an enlightened policy of admitting women, and from the very first days of the geology department photographs of field trips show that women were enrolled in general geology classes. It was the first college in the eastern United States to admit women along with men (1872); provide scholarships specifically for women (1884); and the first to award the Doctor of Science degree to a woman (1895) (Conable, 1977). According to Charlotte Conable's book, *Women at Cornell-The Myth of Equal Education*, however, reality did not match policy (Conable, 1977). She speaks, for example, of how the male fraternities made it a point to exclude female Cornell students from all parties. Jill Ker Conway echoes these conditions:

> "At Cornell, the tension between the men and women was symbolized by the decision of male fraternities to ban any fraternity brother seen fraternizing with the Cornell women at Sage College." (Conway, 1994, pg. 239).

Their analysis is certainly supported by a comment in O. D. von Engeln's handwritten *Reminiscences*, prepared when he was in his 83rd year. In speaking about his days as a student at Cornell during the first decade of the Twentieth Century, von Engeln said:

> "Coeds [at Cornell] were frowned upon and had no part in any social events, for these [events] females were imported, the nearest source was Wells College [an all women's college in Aurora, New York]."[35]

In light of this, Harris' policy of including women among his students went very much against the tenor of the times, and he was the first member of the Department to accept women as graduate students. Even in the 1930s, 1940s, and 1950s some faculty in the Department still refused to admit women for graduate work with them. All through the 1930s and 1940s when the Department held its geological field camp at Spruce Creek, Pennsylvania, no women were allowed to attend because the facilities were less than appropriate to house both men and women, as everyone slept in one room on the second floor (Brice, 1989). In contrast, in 1900 Harris had women at his field camp using tents. Although these were probably less than adequate, at least everyone did not sleep in the same tent. But the use of tents is a story which will come later.

This departmental attitude of excluding women seems to have extended to faculty positions as well; the first female member of the Cornell geology faculty above the rank of research assistant, lecturer, or instructor was Teresa E. Jordan, who was named an

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[33] *New York Times*, June 16, 1985, Section A, p. 28.

[34] Letter from Caroline Heminway Kierstead to William R. Brice, October 26, 1983. HA-PRI, Ithaca, NY.

[35] Page 198, *Reminiscences*, by O. D. von Engeln. Von Engeln Papers, 14/15/856, Box 1, Files 1-44, 1-45. RMC-KL, Cornell.

Assistant Professor in 1983. This fact seems quite surprising, given the department's tendency to hire its own students (as witness Harris, J. Burfoot, C. Nevin, S. Cole, J. Wells, and L. Brown). The quality of the women students was certainly good, for many of them went on to work with various companies and to hold faculty positions at other universities and colleges. Here are career summaries for three, of many, from the early days who became quite successful geologists and teachers of geology:

> Carlotta Joaquina Maury (Ph.B.'96, Ph.D.'02) worked with Royal Dutch Shell Petroleum Company as a consulting paleontologist for many years, and also worked with O. A. Derby[36] in Brazil. She lectured at Barnard College from 1909–1912; was on the faculty at Huguenot College, Cape Town, South Africa from 1912–1915, and organized her own expedition to the Dominican Republic in 1916 after receiving the Sarah Berliner Fellowship in the biological sciences. She served as the official paleontologist for Brazil from 1914 until her death in 1938 (Ogilive, 1986, pp. 131–132).
>
> Katherine Van Winkle Palmer (Ph.D. '25) was Director of the Paleontological Research Institution from 1951 to 1978, and during those years served as editor of the *Bulletins of American Paleontology* and of *Palaeontographica Americana*. She was awarded the Paleontological Society Medal in 1972—the first woman to be so honored.
>
> Caroline Heminway Kierstead (M.A. '28) was a paleontologist with Shell Oil and a professor of geology at Smith College. She retired in 1969.[37]

Why Harris was so supportive of women remains a mystery; he left no comments or explanations on the subject. Perhaps this support had an economic basis because in that time women were paid less than men; he could, therefore, hire more assistants for the same outlay of salary money. Perhaps he felt that women were better suited to the precise and exacting work required in paleontology. Or perhaps, and I would like to think this was the reason, he was sensitive to the aspirations and abilities of women. Perhaps it was because he had several sisters, two of whom were college graduates; he also had a sister-in-law with a D.Sc. His wife, Clara, was certainly a strong person in her own right, and their only child was a daughter and a Cornell graduate. Although in a letter to Heinrich Ries, Harris did present a slightly different attitude towards at least one former female student, Carlotta Maury (about whom more will be said later), he was otherwise universally supportive of women scientists under his tutelage. The letter to Ries was part of a request for funds to purchase Maury's "European collection of Oligocene Tertiary shells . . ." Harris indicated that she spent, ". . . one year and . . . about $600 . . ." Then he went on:

> "I do not want to insult the lady, but it seems to me that in so much as she could not collect at the same advantage as the men could, that if she really wants to sell her collection, she might part with it for some such consideration as $200, at least I would like the privilege of making some such suggestion to her and see what the results would be."[38]

Whatever his motivation for encouraging the women students, paleontology in particular and geology in general were greatly advanced as a result of Harris' acceptance of women graduate students. Perhaps it was Harris's example that made it possible for women to do graduate work with other colleagues. For example, Georgianna Duncan Conant (M.A. '28), who later worked for many years with the U.S.G.S., did her thesis under Dr. Charles Nevin (the same professor who refused to have Caroline H. Kierstead as a student); she also assisted Dr. Heinrich Ries with his molding sands experiments. She was co-author of a paper originating from this work, and edited a revision of Ries's engineering geology text (Brice, 1989).

FIELD CAMPS AND BOATS

One of the most colorful aspects of Harris's teaching at Cornell was his use of boats for field trip transportation and to travel to field sites. Automobile and bus travel were unknown when Harris launched the first of his fleet and most travel was by horse and wagon or train; all were used for student field trips. But because of Ithaca's location on Cayuga Lake, Harris decided that travel by water was better. Not only could the parties get from one place to another easily, but often the shorelines had good rock exposures—not unlike today's highway cuts. For many years, Harris made extensive use of waterways and boats for both teaching and research, and in this he was following in the footsteps of one of his predecessors, Theodore Comstock. Comstock started the tradition of a summer school at Cornell with geology classes in summer of 1876 which had a base camp in a mountainous region ". . . illustrating geological science." (Brice, 1989, pp. 30–31). The following summer, 1877, Comstock took students by chartered steamer on a geological trip along the coasts of the Great Lakes.

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[36] Orville A. Derby (B.S.'73, M.S.'74) 1851–1915; student and colleague of Charles Frederic Hartt at Cornell and worked with Hartt on the Imperial Geological Survey of Brazil 1875–1878; later director of the first Federal Geological Survey of Brazil, 1906–1915.

[37] Personal communication, October 26, 1983.

[38] Gilbert D. Harris to Heinrich Ries, November 8, 1915. Heinrich Ries Papers, 14/15/691, Box 1, File 1-24. RMC-KL, Cornell.

Harris already had the option of using the excursion steamboats that were in operation on Cayuga Lake: the *Frontenac* made her maiden voyage on June 4, 1870, and in 1901 the *Iroquois* and the *Mohawk* joined her on the lake, making quite a flotilla. These were large boats—the *Frontenac* was 135 feet long with a twenty-foot beam and had room for 350 passengers—and although they were fine for taking students to regular stops such as Taughannock Falls, on the west side of Cayuga Lake, or Union Springs, on the east side, Harris felt he needed transportation he could control, making stops whenever and wherever he wished. He sought assistance from the University, and a report in *Science* (Anonymous, 1897; Harris, 1897a) erroneously suggested that the Cornell Trustees were assisting Harris with the construction cost of his first boat *Ianthina*, but the entire $1100.00 came from his own pocket, as did the cost of them all.[39] To appreciate fully how much Harris was investing in this boat, it is useful to note that just a few years earlier he had been hired by Cornell as an Assistant Professor at a salary of $1400 per year! So he was spending an amount almost equal to his annual salary.

The first boat, *Ianthina* (Plate 7), built in 1897 by Lintz and Company of Grand Rapids, Michigan (Harris, 1897a), was named after a mollusk—a practice Harris continued with all his boats. *Ianthina* was shipped by rail from Grand Rapids to Ithaca and launched into Cayuga Inlet in early 1897. She was forty feet long, had a nine-foot beam, and was equipped with both a propeller and a large paddle wheel. The paddle wheel did not prove very useful, though, and was soon removed. *Ianthina* was powered by a two-cycle, six-horsepower gasoline engine that could push the craft along at six miles per hour. *Ianthina* had a "trunk" cabin with six cots and an upper deck used as an observation platform.

The boat was barely in the water before Harris and a small band of students "motored" for Chesapeake Bay and the Carolinas. Among the students who made the trip in the summer of 1897 were Edgar R. Cumings (geology graduate student '97), the "engineer" as he was called, Thomas A. Caine (A.B. '86); and George C. Martin (B.S. '98). For Martin, this trip to Maryland was a harbinger of things to come, for later the Maryland Geological Survey called upon him to prepare the gastropod section of its Miocene volume (Clarke *et al.*, 1904). Despite numerous mishaps on the journey and problems with the paddle wheel, *Ianthina* proved its worth as a means of transportation. The samples the group collected were eventually described by Harris and a student in 1919:

> ". . . material collected by members of the first cruise of the *Ianthina* in Virginian waters in 1897." (Van Winkle and Harris, 1919, p. 6).

Harris was so pleased with the launch that he extolled her virtues in a letter to the editor of *Science*, dated November 5, 1897. He described the first trip, which was a long voyage from Ithaca to lower Chesapeake Bay and return, via the Erie Canal, Hudson River, Raritan River and Canal, Delaware River, Delaware and Chesapeake Canal, Chesapeake Bay and its many inflowing rivers. He also spoke of why he preferred the gasoline-powered launch to one powered by steam:

> "1. Cost—(a) Any well constructed boat 30 feet long, with a 6-horse power gasoline engine will run 800 miles on two barrels of oil; cost about $9.00 on an average, i.e., a little over a cent a mile; (b) while on government waters no licensed engineer or pilot is required. With a few days practice, under the direction of one acquainted with the engine, one learns his engine thoroughly and can as easily go up the Potomac to Washington as navigate his own mill-pond.
>
> "2. Freedom from government inspection.
>
> "3. There being no boiler or fire, the boat is light, roomy and cool.
>
> "4. When stopping at an outcrop no gasoline is being used. The whole machine is at a standstill, dead. But to start up and get under full speed requires less than a minute."

He closed with:

> "Suffice it to say that in a country like our own, well traveled by water ways, a marine laboratory capable of rapid locomotion, at an exceedingly small cost, seems a very desirable adjunct to true university work in natural history subjects." (Harris, G. D., 1897b, pp. 703–704)

Of course, if surviving photographs are any indication, there were times when Harris and his crew had to resort to using a sail, but this information he did not include in his letter to the editor. He also refrained from mentioning the many hours of "tinkering" required to repair damage and breakdowns. Harris' daughter, Rebecca was quoted as saying:

> "My father may not always have used accepted tools or methods but he could make machinery work." (Kiersch, 1964)

Soon *Ianthina* was joined by a faster launch which, because of her narrow form, was christened *Orthoceras*, after the long and slender fossil nautiloid. The new boat was not as costly as *Ianthina*, but just how much it cost is difficult to determine for Harris left conflicting references. In the letter to Ries in May 28, 1929, Harris indicated that $600 was required to get her built and launched. In one of his Annual Reports written just after she was built, however, Harris listed a different figure:

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[39] The cost of the boats comes from a letter Harris wrote on May 28, 1929 to Professor Heinrich Ries, Head of the Department of Geology at Cornell. (H. Ries Papers, #14/15/691, Box 1, File 1-24, RMC-KL-Cornell.) But in an earlier report, Harris gives a slightly different cost for the first *Orthoceras* as indicated in a later paragraph.

> "My large boat *Ianthina* proving too heavy for rapid transit. I bought a much lighter boat last spring, of torpedo model, for $400.00, christening it *Orthoceras*, and in it placed my old engine. This left my old boat with no power. I have just bought a 12 H.P. double cylinder engine for the *Orthoceras* and will reinstall the old engine in the old boat. For this summer's use, then, besides rowboats, I shall have my light and very swift boat and a large, heavy boat for great loads and large classes. Without these additions to my summer work no such complete and sweeping superiority could be claimed for our school over all rivals. They are just what turns the tide in our favor."[40]

This light "torpedo" boat was 5 feet wide but 30 feet long (2.5 × 9.5 meters), and the double cylinder 12 horsepower engine could drive *Orthoceras* at 12 miles per hour (20 kph). This launch was to act as a tender for assisting and towing the larger and heavier *Ianthina*. According to a report in 1902, Harris had both boats in operation by 1899:

> "The first [field camp] trip was in 1899. Professor Harris took five men in one of his launches . . ." (Smith, 1902, p. 396) [Note the use of the plural, "launches."]

Also in his Annual Report for 1899–1901, Harris said:

> "We have built a launch [*Ianthina*] for promoting field investigation in southern waters; we have reconstructed the same for better service in waters nearer by, and now have just purchased a much finer launch [*Orthoceras*], one that will still better serve the purpose we have in view."[41]

Thus, *Orthoceras* must have been purchased sometime in late 1898 or early 1899 and Harris had the "fleet" he needed for the summer work. Certainly by the summer of 1900, both boats were in operation because there was this brief reference in *Science* June 1, 1900 (even though *Orthoceras* was not a *steam* launch):

> "Professor Harris, of the department of geology, Cornell University, will take a class with the steam launch the *Orthoceras* to Lake Champlain for geological work." (*Science* N.S., v. 11, no. 283).

According to the published announcement (Anonymous, N.D.) for what appears to be the 1902 field camp (no date is on the pamphlet, but the class list for the 1901 camp is the last one included in the announcement), both boats were still in operation or at least expected to be in operation for the summer of 1902. John Rich recalled that *Ianthina*, and presumably *Orthoceras* as well, was in operation when he came to Cornell in 1903–04:

> "One feature of Professor Harris' instruction which helped arouse my interest as well as that of many others was the institution of Saturday geological excursions on the Harris launch, Ianthina, to various points of interest along the shores of Cayuga Lake. In the summer of 1904, Professor Harris took a group of us, including F. L. Whitney, Leopold Reinecke, of South Africa, and Joviano Pachecho[42], of Brazil, on a longer trip on his fast launch [*Orthoceras*] from Ithaca down Cayuga Lake and thence along the Erie Canal to the neighborhood of Albany, where we were joined by a larger group of students for two weeks camping and geological scouting in the Helderberg Mountains."[43]

About that time or shortly afterward, however, a boat house fire destroyed both boats. This was no doubt a devastating loss for Harris, but, to date, no record has been found as to how this disaster affected him or his programs, nor has the exact date of the fire been determined.

Not to be stopped by the fire, Harris had *Orthoceras II* (cost $500.00) constructed to carry on the field activity for the last few years that the field camp existed. In 1905 Harris attempted to sell "a launch" to Cornell;[44] which one is not known. Also, there seems to have been another boat between the time of the fire and 1914 that has not been mentioned in any of the Harris memorials:

> "You remember how we studied and worked over the engine of our boat 'Prexy' and you said that in case it ever ran you would like to know what means I used to get it started again. You remember there seemed to be imperfect compression so I purchased some brand new piston rings and put them in in [*sic*] place of the ones which we spread out last year , [*sic*] and there was no difficulty in starting

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[40] *Annual Report to the President of Cornell University of the Department of Paleontology and Stratigraphic Geology*, by Gilbert D. Harris; May 15, 1901, p. 5. HA-PRI, Ithaca, NY.

[41] *Annual Report of the Department of Paleontology and Stratigraphic Geology;* 1899–1900 by G. D. Harris, p. 4. HA-PRI, Ithaca, NY.

[42] Joviano Augusto d'Amaral Pacheco (Cornell University A.B. '04) worked with Harris in the Helderberg Field Camp and with the Louisiana Geological Survey. Later he was part of the Brazilian Geologic Survey.

[43] John L. Rich to Axel Olsson, February 21, 1953. HA-PRI, Ithaca, NY.

[44] A notation about not wanting to sell any of the Paleontology collection, nor wishing to purchase Harris' launch. Cornell University Trustees meeting minutes, December 5, 1905.

> the engine and it has run splendidly ever since. This I did but a few weeks ago, not having time all last summer to touch it."[45]

This is the only reference to *Prexy* found in the Harris Archive and nothing is known about her size, etc., or her final disposition. *Prexy*, however, must have been another boat because that name does not seem to be a familiar or shortened form of *Orthoceras*, nor is it the same as *Pecten* or *Pecky*, the name of a small dinghy Harris owned at the same time as *Ecphora*. Also, one would not expect a dinghy to have an engine in it. So, it appears that Harris had yet another boat after losing the first two in the boat house fire.

HELDERBERG FIELD CAMP

The very first summer Harris was at Cornell, he was out in the field, and he had received funding for expenses from the Cornell Board of Trustees:

> "In the spring of 1895 the Trustees of Cornell University generously appropriated the sum of $400 to be expended in geological and paleontological research in the Tertiaries of our Gulf and Atlantic coast states. This sum was for defraying the field expenses of the writer and one assistant who were to volunteer their services during the following summer vacation in the field specified. Accordingly Mr. W. S. Hubbard[46] and the writer left Ithaca in the latter part of June, and after visiting west Tennessee, northern and central Mississippi, central Alabama and Western Georgia, returned North in the latter part of August. . . .
>
> 'It is scarcely necessary to say that during the summer season in the south it is often extremely warm, and trying to one's health; and the writer, as well at the University at large, is deeply indebted to the skill, strength, good-will and never-tiring zeal of Mr. W. S. Hubbard." (Harris, 1896a, pg 119–120).

The next summer, he and Hubbard were back out in the field with the Trustees granting him another $400.00, this time to return to the Gulf and Atlantic coasts (Harris, 1897c). The fact that Hubbard, who was not even a geology student (Anonymous, 1908), would spend two summers doing field work with Harris is a good illustration of the influence he had with students, even non-geology ones.

But very soon Harris' summer activity was much more organized and involved more students. As indicated earlier, Harris' involvement with summer field camps (Brice, 1994a, 1995) also followed a Cornell Geology Department tradition started by Professor Theodore Comstock in 1876 (Brice, 1989, p. 30). Harris appeared to have been motivated by two factors. First was his desire to instruct students in techniques of field geology:

> "The Helderberg School of Field Geology is the outgrowth of a strong desire of the Department of Paleontology and Stratigraphic Geology at Cornell University to teach geology in the most practical, natural and efficient way at the least possible expense to the student." (Anonymous, N.D., First page, but no page numbers printed).

These phrases are quite similar to what Harris used in his Annual Report for 1899–1900, the same year that the major field camp effort began, and these ideas seem to be central to his teaching.

Secondly, Harris became the "Geologist-in-Charge"[47] for the Louisiana Geologic Survey in 1898 and needed to change his teaching schedule to free part of his year to work in Louisiana. Given the Ithaca winters, Harris chose to spend that season in Louisiana, and his classes were held during the fall and summer months to fulfill his teaching obligation to the University. According to a card Harris printed[48], he was in Louisiana from December 15 until March 15, and then at Cornell from March 15 to December 15; away from Ithaca just long enough to miss the worst of the winter weather. While he was head of the Survey in Louisiana, Cornell paid Harris $1500.00 while his colleagues were receiving $3000.00[49]. Even though he was in Louisiana only three months a year, there was, no doubt, Survey business to conduct while he was in Ithaca. It took him a year or so to get this "winter-off-for-summer work" arrangement approved[50]:

> "We have, finally, exchanged the winter term of our year for the summer, and have established a school of practical geology in eastern New York, in the heart of the most classic geological country of the continent."[51]

The field camp was an efficient way for Harris to attend simultaneously to his duties as Geologist in

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[45] Unsigned carbon copy, Gilbert D. Harris to F. L. Whitney, May 11, 1914. HA-PRI, Ithaca, NY.

[46] Walter Stacy Hubbard was at Cornell 1882–85 and 1894–96. He was not a geology student and received a Bachelor of Letters in 1895. He died in Buffalo, New York June 6, 1908.

[47] Title on a printed card prepared by Harris which includes A. C. Veatch, Assistant State Geologist. HA-PRI, Ithaca, NY.

[48] HA-PRI, Ithaca, NY.

[49] Letter from President Schurman of Cornell to H. Ries, Head, Department of Geology, May 28, 1915 (Ries Papers, #14/15/691, Box 1, File 1-22; Budget request from H. Ries to President Schurman, May 29, 1915. RMC-KL, Cornell.

[50] Harris gained official approval to take a winter vacation and do equal work-time after the close of the regular spring term; Cornell University Trustee meeting minutes for November 1, 1899.

[51] Page 4 of the "Annual Report of the Department of Paleontology and Stratigraphic Geology; 1899–1900" by G. D. Harris. HA-PRI, Ithaca, NY.

Charge of the Louisiana Geological Survey, meet his teaching obligation, and provide a marvelous educational experience for the students. Consistent with his philosophy of teaching, he felt that:

> "To have knowledge, then, at first hand of New York's type sections, must necessarily be the ambition of every young and true student of geology." (Anonymous, N.D. p. 2).

In addition to the regular college students, Harris also welcomed secondary school teachers to his camp and modified the course of study to fit their particular needs. In the prospectus describing the planned 1902 field camp program Harris put in a special section directed toward the secondary teachers:

> "To the high school teacher to whom falls the lot of teaching the sequence of formations, their characteristics and fossils, without having at command his own fossils, or drawings and photographs, of his own make, of Trenton, Oriskany and Niagara falls; the Adirondack, Catskill and Helderberg mountains; and the thousand and one little objects and sketches that go to fill up and vivify bare text-book outlines-no longer is pity nor tolerance due, since the means are now at hand for gaining the requisite knowledge and material at a very small expense." (Anonymous, N.D., p. 2).

That small expense amounted to about $75.00 for the summer: this included university tuition of $25.00, fees for tents and cots set at $10.00, the various side excursions cost an additional $10.00, and living expenses of about $3.00 per week. For that investment, students could take as many as 10 credits depending on how much time was spent in the field activities. The course ran from June 26 until September 4, with a concurrent six-credit, six-week session from July 7–August 16. Later in the 1930s when the Department began another field camp, this time in the valley-and-ridge region of central Pennsylvania, the cost was $150.00, which included $60.00 for tuition.[52]

Harris' great concern for the education and training of secondary teachers clearly went beyond the field camp activities, for in a course description he prepared for "Course 25", he explained what he hoped they would really learn:

> "The object of the course will be to show how the geology of a region is actually worked out, mapped and reported upon. It is felt that a teacher, in order to fully realize his or her opportunities in teaching geology, should be able to work out systematically and carefully the geology of the region where the teaching is to be done. Take away the pleasure and stimulus of local, 'near-at-home' references and the subject becomes tedious to teacher and pupil."[53]

LIFE IN THE CAMP

The Harris field camps were unconventional in many ways. Using the boats certainly made them different (Harris, 1900), as did his encouragement of the secondary teachers, and he continued to encourage women students. Lillian B. Sage[54] not only attended the 1900 field camp, but she returned the following year as an instructor. The letterhead stationery Harris printed for the 1901 field camp had a map on it showing the camp location and the excursion routs marked with a red line. Also the staff list included, "L. B. Sage, *Methods in Mapping*." The letterhead itself is interesting in the way Harris included the University:

"HELDERBERG SCHOOL
OF
FIELD GEOLOGY

Under the auspices of the
Department of Paleontology and
Stratigraphic Geology of
CORNELL UNIVERSITY."[55]

According to the pamphlet describing the proposed 1902 program (Anonymous, N.D.), after 1899 the number of women students increased, *e.g.*, 4 of 15 in 1900 and 14 of 27 in the 1901 camp. In 1901, two of the women are listed as Mrs., and according to the department records (Brice, 1989), not all of the women were school teachers; several were geology students studying at Cornell and other universities such as Mount Holyoke and the University of Michigan. By contrast, the information prepared for another department field camp begun in 1930 specified, "Registration is limited to men."[56] because the living facilities were "not adequate." This seems a very weak excuse, for the tent facilities Harris used 30 years earlier were far from ideal, and yet he happily welcomed women students to his camp.

As mentioned above, the living quarters for the field camp consisted mostly of tents furnished by the department:

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[52] Draft of field camp announcement, no date, but assumed to be for the summer of 1931. Ries Papers, #14/13/691, Box 2, File 2-8; RMC-KL, Cornell.

[53] From "Information Regarding Courses 21 and 25" [no date, but assumed to be c. 1900 for A. C. Veatch and Percy Raymond were the assistants]. HA-PRI, Ithaca, NY.

[54] Lillian Belle Sage (A.B. '01). By 1905 she was a teacher in Brooklyn, New York (Hewett, 1905, v. 4, p. 475).

[55] Letterhead stationery with a partly colored map showing the excursions for 1901. HA-PRI, Ithaca, NY.

[56] Draft of field camp announcement. Ries Papers, #14/13/691, Box 2, File 2-8. RMC-KL, Cornell.

> "For summer expenses, mostly for camp equipment, the appropriation of $500.00 has been made by the executive committee. The money will be used, but the equipment will last for a number of seasons."[57]

The camp had:

> ". . . (1) a large assembly tent, (2) a tent or building for drawing and laboratory work, books, museum specimens, instruments, etc., (3) a space set aside for preparing the rations of each mess [meal], and (4) 25 wall tents, with two cots in each, for the accommodation of 50 persons." (Anonymous, N.D., p. 4).

The "museum" portion included a set of labeled fossils from each of the sections the students would be examining.

The students were divided into different parties according to their background and given tasks appropriate for their capability. Those with experience went directly to the various mapping projects, while the less experienced students had 10 days of intensive lectures in addition to the material they were expected to read before attending the camp. One suggested reference was Dana's *Geological Story Briefly Told* . . . (Dana, 1875). As with all good geological camps, when the field work began, it began in earnest, and echoing H. S. Williams, the students were told that the best way to measure and investigate a stratigraphic section was:

> "By commencing at the base of the mountain, and collecting from each and every bed until the top is reached, the student has then in his possession material from which it is possible to construct a geological section of the region." (Anonymous, N.D., p. 6).

With such strenuous activities, meals take on added importance, and in this camp the students were their own cooks:

> "Questions are often asked as to how food is provided and served in camp. This, however, is a simple matter. Camp is divided usually into messes [meal groups] of about four to eight congenial souls each. A few cooking utensils are bought and some supplies ordered from a nearby village store. The honors of purchasing, cooking and caring for the culinary property of each mess are divided as equally as may be among its various members. Here comes in play "natural selection", "survival of the fittest", etc. Sufficient heat is furnished by camp fires or oil stoves. The services of a hired "chef" have thus far been done away with, tho' [*sic*] no complaint could be made if a mess should decide to employ such a person." (Anonymous, N.D., pp. 7–8).

Sleeping accommodations were cots supplied by the university, but students were directed to bring, ". . . two sheets and six blankets . . ." They were cautioned to keep their belongings to a minimum and to bring only old clothes suitable for summer work out-of-doors:

> "It is a serious impediment to work to be clothed too heavily, or to have to be ever on the alert to keep from soiling one's clothes." (Anonymous, N.D., p. 8).

While the evenings were to be filled with the usual field camp tasks, such as drafting sections, working on samples, etc., Harris did set aside time for lectures at least twice a week. These lectures, prepared by the advanced students, were illustrated by lantern slides, but no mention is made as to how the lantern slide projector was powered. Perhaps these truly were "lantern" slides. After the close of an evening's activity, the students frequently gathered around the camp fire, and Harris had planned for that activity as well. Among the field camp related material is a small booklet with a cardboard stock cover and bound with red cord, entitled "Fossil Fragments for Fireside Frappe-ing"[58]—the camp song book. Among the 26 songs are many old favorites known today, including, "My Old Kentucky Home", "America", "Tavern in Our Town", and "Mandalay." Others included are not so well known today, such as, "Soldier's Farewell", "Who Did?". "The Mountains", and "Romeo and Juliet." Campus loyalty was expected, so several campus songs of Cornell were included, "Cornell", "Cornell Rowing Song", and the Alma Mater. As the camp was open to other universities, Harris also included "Fair Harvard", and "The Orange and the Black" (Princeton). Also among the songs was not one, but TWO verses of "The Star Spangled Banner." If you listen closely on a quiet summer night in upstate New York, it is easy to imagine the lively voices raised in song still echoing off the Helderberg hills, ". . . led by the Professor's ringing tenor" (Herrick *et al.*, 1953, p. 14A).

FIELD CAMP ACTIVITIES

In 1899, the year after he became Geologist in Charge of the Geological Survey of Louisiana, Harris conducted a modest field excursion with only five students: T. A. Caine (Nunda, NY), W. M. Chapman (Elmira, NY), H. F. Cleland (geology graduate student '01, New Haven, CT), W. E. Thro (Elmira, NY), and J. Pacheco (A.B. '04, Saõ Paulo, SP, Brazil) (Anonymous, N.D.). Cleland and Pacheco attended several field camps and probably functioned as field assistants for Harris. Another member of the 1900 camp was A. C. Veatch, mentioned above.

Because of its proximity to many fossil-rich beds and other interesting geology, Trenton Falls proved a good choice for the camp headquarters in 1899 and a more permanent camp was created there for the 1900 field camp (Anonymous, N.D.). From the camp headquarters they took excursions by boat to Lake Champlain and through the Mohawk River valley via the Erie Canal. Then for the next few years, certainly for 1901 and 1902, Harris moved the headquarters of the field camp to the Helderberg Mountains in the Country Man Hill section:

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[57] *Annual Report to the President of Cornell University of the Department of Paleontology and Stratigraphic Geology*, by Gilbert D. Harris; May 15, 1901. HA-PRI, Ithaca, NY.

[58] Private collection, WRB; now at HA-PRI, Ithaca, NY.

> "The Helderbergs have been chosen for our camp or *rendezvous* this summer in place of Trenton Falls for various reasons: 1st, they show in one section ten geological formations; 2nd, they are more central, excursions can radiate out down the Hudson, up Lake Champlain, and west on the Erie canal." [59]

This camp was to cost about $65.00 for the six weeks (Anonymous, N.D.; Smith, 1902). Students could reach the camp location from Voorheesville, ". . . by special conveyance at a moderate price for person and baggage."; special conveyance was a horse and wagon. The nearest large city was Albany, ". . . being about 15 miles a little north of east from the camp." (Anonymous, N.D., p. 4). Three side trips were undertaken in 1901 using the boats, (1) to Lake Champlain as far as Plattsburg, (2) down the Hudson River to Rondout, and (3) along the Erie Canal back to Ithaca at the end of the session. The group was to spend two weeks at Valcour Island in Lake Champlain completing a survey started in 1900. In addition to the boat trips, students could take a train to visit AuSable Chasm and as far north as Georgia, Vermont.

During the first six week of the 1902 field camp, Charles E. Smith (A.B. '02) and others spent time working on the stratigraphic section at Indian Ladder. This is a famous area of Devonian rocks exposed near Albany that have been visited and studied by many famous geologists including Amos Eaton, James Hall, and Charles Lyell. During the last three weeks of the camp, the group worked at Oriskany Falls, including a trip on foot from New Salem to Oriskany Falls. At this time, topographic surveys for that part of the state were not well advanced or totally accurate, but it was important to have accurate elevations for the measured sections. To get these elevations, it was necessary to start at a point of known elevation, a bench mark, and survey elevations from the bench mark to the work site. To accomplish this during the 1902 session, Harris and the students ran spirit level lines from a new U.S.G.S. bench mark at East Berne around to all the sections being measured and over to a New York State Survey triangulation station on Countryman Hill, a distance of about 12 miles (almost 20 km). Each line was run in duplicate to ensure accuracy. This procedure allowed the measured sections to use sea level as a vertical reference point.

THE LAST DAYS OF THE CAMP

Although various field camps continued for another seven years after 1902, no detailed record of those activities has survived. In the introduction to a groundwater report, Harris states that he was doing field work in Louisiana from ". . . June 20, 1903 to July 20, 1903 . . ." (Harris *et al.*, 1905, p.1), so if he held a field camp, it could not have been during those four weeks. Hewett (1905) states:

> "Since 1899 Professor Harris has been state geologist for Louisiana, spending the time between Christmas and Easter in that state, and, *with the exception of the year 1903*, conducting a regular summer session of ten weeks in field geology and paleontology in the Helderberg Mountains and on Lake Champlain." [Emphasis added.] (Hewett, 1905. Vol. II, pp. 236–237).

Based upon the information above, it appears there was no field camp in 1903. The surviving letters from that year give no hint as to reason, but Harris was very active with his geological work in Louisiana that year.

Based on a diary entry by Henry Shaler Williams for May 30, 1904, Harris was in the field for summer, 1904: ". . . [Harris] into field—Cent. [*sic*] NY & Helderbergs from June 15–July 15 . . ."[60] Also, John Rich, in his letter to Axel Olsson mentions the 1904 camp, but, as indicated in the previous quotation from that letter, by 1904 the time spent in the field had been reduced to about two weeks.[61] Palmer (1953c) stated that all the field camps from 1898 through 1909 were held in the Helderbergs, but according to Olsson (1954), after 1902, only the 1904 camp went back to the Helderberg area. During the 1904 season Rich, Francis. L. Whitney (A.B. '06), Leopold Reinecke (M.A. '09, from South Africa), and Joviano Pacheco (São Paulo, Brazil) helped Harris trace the contact between the Devonian and Silurian rocks from Cayuga Lake to the Helderbergs. This work was published by Harris (1904, 1905a) and provided, perhaps, another valuable lesson for the students. Nowhere in the 1904 publication does Harris indicate that he had any assistance with the work; there is not even an acknowledgement section listing the students from several different field camps who worked on the various stratigraphic sections he described. In the small pamphlet on the geology of Union Springs published by Harris in 1905, however, he did acknowledge the work of Pacheco, Rich, and Whitney, and another student, C. A. Tracy, who apparently originally started the project.

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[59] *Annual Report to the President of Cornell University of the Department of Paleontology and Stratigraphic Geology*, by Gilbert D. Harris; May 15, 1901; pp. 5–6. HA-PRI, Ithaca, NY.

[60] Diary of Henry Shaler Williams, p. 128, file 3-9, Box 3, H. Ries Papers, #14/15/691, RMC-KL-Cornell.

[61] John L. Rich to Axel A. Olsson, February 21, 1953. HA-PRI, Ithaca, NY.

In any event, 1909 was the last summer Harris held the "Helderberg School of Field Geology."[62] This was also the same year he ceased being the Geologist in Charge for Louisiana, apparently because funding for the Survey was not continued by the state legislature (Pope, 1988), the same difficulty Harris had faced in Texas earlier. The conjunction of the two events, the demise of the Louisiana Survey and his last Helderberg field camp, may be just coincidence. A series of letters and notes which passed among Ries, Harris, and Acting Cornell President Thomas F. Crane in December of 1912 tends to suggest that the two had no direct connection, but this is open to interpretation; especially considering what Harris said in a letter written the following year:

> ". . . I shall be occupied most busily all summer in oil investigation . . ."[63]

Among the Ries papers is a note, probably written by Ries in December 1912, which stated the following:

> "For several years, Professor Harris has been granted leave of absence from approximately the middle of December to the beginning of the second term, for the purpose of going to Louisiana where I understand he is interested in some private work. In return for this privilege he offered to conduct, and has conducted a geologic field excursion in summer lasting from five to six weeks."

In the Ries file, the above note is attached to a letter from Harris to Crane, December 10, 1912, in which he requested a shift of six weeks after the Christmas Holiday recess until the end of the first term for the six weeks in the summer. He said that he wanted to, ". . . enter the field of commercial geography during the winter six weeks . . ." Harris went on to state more of his reasons for the request:

> "My reason for discontinuing [the summer field course] was that the $1500 salary I was receiving was not ample for additional equipment and by taking undergraduates or students of that rank they could not be properly cared for. Now I have several times that income and shall limit my [summer] class strictly to those who are going to devote their lives to geology."[64]

Harris, next, gave examples of former students who had become successful geologists after studying with him at Cornell. One was A. C. Veatch, mentioned earlier, who had been working as a geologist for Barber Asphalt Company in Venezuela with a salary of $10,000 per year. A few days later Harris received permission to take a leave from Christmas to the beginning of the second term.

In 1913, apparently Harris was forced to examine his situation. The arrangement of trading time in the summer for part of the regular academic year at Cornell that Harris, the "Geologist in Charge", needed to perform his duties for the State of Louisiana, now Harris, "The Consultant", found advantageous as well. He wrote to the Cornell President:

> "As to the general plan for the future, I see two roads open before me : [*sic*] (1st) To largely withdraw from elementary teaching, and devote myself to the materials which I have been collecting these 15 years past, aiding and encouraging only such students in like work as chance to come my way and seem particularly fitted for museum work and research in general—trusting that the beginnings of geology, by whomsoever given will be impartial and will naturally tend to bring a few students each year my way. (2nd) To organize a beginning course in Geology for Arts [*sic*] students, with the intention of making several such students research workers in Paleontology and Stratigraphic Geology. This course has already been suggested to me by [former] President Schurman and the present Dean. But, I have concluded, insomuch as it has been directly expressed to me that the Executive department of this University prefers me to confine my efforts to special and perhaps graduate work, and insomuch as there is now no museum help at all with thousands, yes, tens of thousands of specimens needing attention, I shall prefer for the coming year to not announce any elementary new work.
>
> "Had I not felt the need of work being done immediately and in goodly quantities in the museum, I certainly would have asked for a sabbatical leave of one-half year to attend to an offer from the University of California[65]. It would have been a great thing for me personally in several ways. . . .
>
> "Allow me to thank you for the arrangement by which I give my students, in the summer, field work in the North; in the winter field work in the South."[66]

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[62] Printed letterhead used before the 1901 field camp. HA-PRI, Ithaca, NY.

[63] Unsigned carbon copy, Gilbert D. Harris to Charles Schulz, May 19, 1913. HA-PRI, Ithaca, NY.

[64] Gilbert D. Harris to Acting President Crane, December 10, 1912. The undated memorandum by Ries is attached to the Harris letter. Heinrich Ries Papers, 14/15/691, Box 1, File 1-22. RMC-KL, Cornell.

[65] No record of such an offer exists among the Harris papers. HA-PRI, Ithaca, NY.

[66] Unsigned carbon copy, Gilbert D. Harris to "President Crane" [Thomas F. Crane], April 28, 1913. HA-PRI, Ithaca, NY.

Although earlier Harris had indicated to Crane his desire to do more commercial work, nowhere in this letter does Harris mention the fact that now he was involved with these commercial ventures and that the field work the students were doing in the south was related to this activity. Also, it would appear that perhaps some of the museum's pressing needs could have been addressed by Harris staying at Cornell for the entire year, but to do that he would have had to forego the consulting work.

So in 1913, Harris continued an informal summer field program when he and small group of students worked in southwestern New York and northwestern Pennsylvania (Olsson, 1954) for about a month:

> "I shall not be here [at Cornell University] from the 5th of June to the 5th of July, but shall be here several weeks during the Summer Session, [I will be] leaving here shortly after the 20th of July for the south; . . ."[67]
>
> "We are going for a few weeks [to a] geological summer camp in the vicinity of Warren Pa., . . ."[68]

The material collected in Pennsylvania eventually found its way into the hands of Kenneth Caster, a student of Harris, who described the fossils and acknowledged the:

> ". . . students at the Cornell Summer School of Geology at Stoneham, Pa., . . ." (Caster, 1930, p. 146).

Based upon the surviving correspondence, Harris spent several months in the south in 1913, for he received mail in Louisiana in September,[69] and his typed letters, with a secretary's initials on them, do not resume until September 29. Also, Harris wrote to Dall in October, 1913:

> "I am back safe from a hard summer's work in the south and feel unusually well and ready for work, . . ."[70]

Thus, he would not have had much time for conducting a geological field camp during the summer of 1913.

The same leave request was made the following year, and in 1914 Crane simply gave him an indefinite extension of the substitution privileges. Harris was again in the south during the summer of 1914:

> "I am planning to be away on my boat trip from June 10th until the latter part of July and from then on the remainder of the summer I shall probably be in Louisiana, . . ."[71]

So Harris continued the non-university winter activity, mostly in Louisiana, after ending the field camps, but now he was involved in commercial ventures. For a few more years he used the summer for field activities but with fewer students. Very soon, however, he had a new boat built for that purpose, *Ecphora*.

For the students, the Helderberg field camp was an experience that literally lasted a lifetime. This is illustrated by the following quotation taken from a Christmas card sent to Harris in 1938 by Miss Emma C. Robinson, a member of the Helderberg Camp in 1900. In the age of satellite images and computer mapping, it is difficult to understand what geology and geology teaching were like when what might be called the "fast lane" was a boat that sped along at five or six miles per hour. I wonder if the present day students will develop and sustain the feelings and memories such as those expressed by Miss Robinson almost 40 years after attending the Helderberg camp:

> "Dear Professor Harris and Rebecca [Harris' daughter]:
>
> "Christmas greetings from one of the old camp fire group. The pattern of my life has changed greatly since those days but through it all runs the thread of joy and gratitude that I could share those days with the Harris family.
>
> Yours Sincerely,
> Emma C. Robinson"[72]

This was certainly a view shared by Harris, for of his time with the Helderberg field camps, Herrick *et al.* (1953, p. 15A) said:

> ". . . he held those days to be the happiest of his life."

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[67] Unsigned carbon copy, Gilbert D. Harris to F. L. Whitney, May 26, 1913. HA-PRI, Ithaca, NY.

[68] Unsigned carbon copy, Gilbert D. Harris to George H. Girty, June 4, 1913. HA-PRI, Ithaca, NY.

[69] Post Card from Floy Harris to Gilbert D. Harris postmarked September 1, 1913 and addressed to Alexandria, Louisiana. HA-PRI, Ithaca, NY.

[70] Unsigned carbon copy, Gilbert D. Harris to W. H. Dall, October 4, 1913. HA-PRI, Ithaca, NY.

[71] Unsigned carbon copy, Gilbert D. Harris to F; L. Whitney, May 11, 1914. HA-PRI, Ithaca, NY.

[72] Emma C. Robinson to G. D. Harris, Postmarked Black Mountain, NC, December 16, 1938. HA-PRI, Ithaca, NY.

CHAPTER 4. *ECPHORA*

The closing of his Helderberg field camp did not stop Harris from working with students in the field, but thereafter the trips were not associated with formal class situations. The loss of his boats in the fire around 1905 did stop some of his water trips because *Orthoceras II* was not large enough for more than a few people at a time, and she certainly had limited sleeping accommodations. So the few trips were taken by the newest mode of transportation, the automobile. But his heart remained with the idea of using a boat, and he soon had another one. As two of his students wrote after the 1915 trip:

> "Not many mountains or other geological formations can be persuaded to leave their native resting place to come to college, and this is perhaps why the ancient saying about Mohammed and the mountain finds a parallel in geological instruction at Cornell University. For many years it has been the custom of Professor G. D. Harris, of that institution, to organize a summer course in field geology, that his students may see for themselves formations and places they would otherwise know only from books, and that they may collect with their own hands the fossils they study during the winter." (Schmidt and Olsson, 1916, p. 15).

In 1914[1] Harris launched his fourth and largest boat. *Ecphora*, designed by M. M. Whitaker (Nyack-on-Hudson, NY) and constructed by the Champaign Brothers Boat Works on the Inlet in Ithaca at a cost of $1,000 (Plate 5). She was thirty feet long, almost nine feet at the beam with a draft of three feet, and she carried two 40 gallon gasoline tanks. There were sleeping accommodations for six people; two bunks, two canvas beds suspended in the cabin, and two canvas stretcher beds in the cockpit. The galley consisted of a two-burner kerosene stove with compressed air in the aft section of the cockpit (Schmidt and Olsson, 1916).

Harris must have rebuilt his boat house after the fire that destroyed *Ianthina* and *Orthoceras I*, but it was not adequate for *Ecphora*. Thus, he attempted to purchase some land from Roger B. Williams, son of H. S. Williams, along the Ithaca Inlet:

> "In endeavoring to put into practice a scheme I have been teaching geology at first hand in the field I desire to construct a fairly good sized boat wherein I may accommodate comfortably such students as would profit by exceptional advantages in geologic work.
>
> "Over and above the expense of all this comes the question of the housing of such a craft. Now I have a boat house already for my own use, but this [new] boat I would have to house somewhere else. Knowing that the Williams estate owns some property on the west bank of the Inlet, I believe just north of the Intercollegiate Crew House, I am writing this to see if you cannot help me in this work to the extent of selling me say 15 or 16 feet front on the Inlet running back to the street to the west, I believe something like 60 feet, and if so kindly advise me at what rate per foot you would be willing to sell it."[2]

The correspondence does not indicate whether he was successful or not, but *Ecphora* was kept in a boat house on the Inlet.

As with previous boats, Harris turned to a mollusk for the name; *Ecphora* is a Miocene gastropod guide fossil, and later he was to use it as the symbol for the Paleontological Research Institution. In a letter to his former student, A. C. Veatch, just after Veatch made a $1,000 contribution to Cornell for Harris to use, he indicated what he hoped to accomplish with the launch and he described the new boat and his ambitious plans:

> "*Ecphora*, 8 1/2 × 30' with 30 hp. 4 cyl. 4 cyc engine. My plan is simply this: to have students go and get their own data from mother earth; to have enormous collections of good material accumulate here; to exchange and sell enough to largely meet actual expenses in the field; to use the same funds therefore over and over again; to have each student feel under obligation to return value received by way of materials, getting his pay in training and general experience; to have such collections as go out, labeled in the most accurate manner possible and mounted in the most approved permanent, and artistic manner; . . ."[3]

Ecphora was barely wet when, just four days after launching, on June 19, 1914, Harris and six students began a three-month voyage that covered some three thousand miles. Only a few weeks before Harris was trying to raise money for the fuel through the University and explaining how valuable the resulting collections would be:

> "I have to report that I have practically completed my personal cruising outfit and have selected seven first class men to help do collecting down the Atlantic coast, in the Tertiary formations during a period of 6 weeks, and I am now asking you if the sum of not to exceed $100 for fuel I mentioned formerly will be available by a week from today [*sic*]. You remember that I have stated that the col-

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[1] The craft was constructed in the early part of 1914, ". . . I am building a large boat . . ." Unsigned carbon copy, Gilbert D. Harris to I. Perrine, March 23, 1914. HA-PRI, Ithaca, NY.

[2] Unsigned carbon copy, Gilbert D. Harris to Roger B. Williams, March 16, 1914. HA-PRI, Ithaca, NY.

[3] Letter from Gilbert D. Harris to A. C. Veatch, no date, but written in response to Veatch's donation made October 25, 1915. Copy at HA-PRI, Ithaca, NY.

> lections will be worth several hundred dollars perhaps $1000 and that you were kind enough to say that there should be no trouble in raising the $100 under such conditions."[4]

But Harris was having some difficulty with the new "channels" that had been created recently with the appointment of Heinrich Ries as Department Head. President Schurman responded to Harris' request with these words:

> "I have just received your communication of June 2nd (which by error is dated May 2nd) asking for an appropriation of $100 for fuel for your trip to collect material down the Atlantic Coast.
>
> "Please talk this matter over with the Head of the Department of Geology and have him in the usual way forward your communication with his endorsement thereupon."[5]

He must have received the fuel money, for the group went as far south as New Bern, North Carolina before turning *Ecphora's* bow northward; a three-month journey of over three thousand miles. The students were Victor Elvert "Monty" Monnett (Ph.D. '22), Parkin "Park" Wong (M.A. '14), Oliver N. "Ollie" Olson ('20) (not to be confused with Axel A. Olsson, who was on the trip the following year)[6], Karl P. "Hans" Schmidt (A.B.'16)[7], Henry R. "Sunny" Sunball ('16), and Lloyd G. "Nellie" Grinnell ('16). (Olson, Sunball, and Grinnell did not major in geology, although they studied with Harris.)

"Nellie" Grinnell kept a very lively and descriptive diary of their adventures on this trip. This journal and accompanying photographs (e.g., Plate 6) were presented to Harris on October 2, 1944, his eightieth birthday[8]. The diary forms the basis of the following account which gives the general flavor of the trip. Not only does Grinnell's diary describe the important paleontological collecting they were able to do, which included several new species, but it also illustrates the closeness and camaraderie that developed among the group, and especially between Harris and his students.

The voyage had an ominous beginning. That first day engine trouble and very stormy weather kept the party from getting out of Harris's boat house on Cascadilla Creek near Steamboat Landing where they all spent their first night—Harris sleeping on the floor of the boat house and the boys sleeping either on *Ecphora* or *Orthoceras II*. The following morning they made another attempt to leave Ithaca, but first they had to dredge up the starboard light, which had fallen overboard during the night. The engine problems also had not been totally solved and required further diagnosis and cure. Then the group was delayed (for some unknown reason) by the "R. H. McGreeny Funeral." But, finally, at about 1:00 P.M., they cleared the Inlet lighthouse, "thumbing our noses at it as we sped by." They were making about "six miles per hour, or knots or crinoids or something," and had the Cornell pennant flying from the masthead[9]. After about seven hours the group reached the Montezuma Lock at the north end of Cayuga Lake. Here disaster almost overtook the party, again:

> "We were raised up in a lock and were ready to start on. Our engineers, Prof. Harris and Hans, started the engine backwards and the boat was plowing backwards, nearly slamming the back deck into a bridge, but just in time Sunny used his head, reversed the propeller and we went ahead." (June 20, 1914)[10]

With the engine restarted in the proper direction, they continued along the Erie Canal for two days to Pattersonville, New York where they were joined on June 23 by Ernest Rice "Sister"[11] Smith (a geology graduate student '13–'19). Pearl Sheldon (A.B.'08, M.A.'09, Ph.D. '11) and Eleanor Long (A.B.'15), also from the Cornell geology department, met the group there, and spent the day with them collecting fossils. Long stayed on board as far as Albany. Later, in the Washington, D.C. area, they were joined by Harris's brother, Rollin, who stayed with the party for part of the day on July 19.

As they reached each suitable collecting area, *Ecphora* would be tied up to a jetty or anchored and the crew would visit outcrops and quarries to study the exposed geology and make collections. On Chesapeake Bay near Herring Bay, according to Grinnell, they spent more time collecting berries than fossils. A similarity between many present-day geologists and these 1914 adventurers appears in the diary entry for July 1, when they were at Chesapeake Beach: "In the evening we went ashore and bought can openers and some Schlitz beer, the first we had since Hudson, N.Y. on June 25th."

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[4] G. D. Harris to Jacob G. Schurman, May 2, 1914 [with June inserted above May]. Schurman Papers, v. 34, Pg 256. RMC-KL, Cornell.

[5] Jacob Gould Schurman to G. D. Harris, June 2, 1914. Schurman Papers, 3/4/6, v. 34, Pg. 256. RMC-KL, Cornell.

[6] An article about the trip in *The Ithaca Journal*, June 6, 1914, lists A. A. Olson as a member of the party, but L. G. Grinnell's diary has the names as they are listed here. Also, A. A. Olsson's name is spelled differently and he did not use the nick-name of "Ollie." The newspaper article is incorrect.

[7] The nick-name "Hans" came from the name of a famous murderer of that era, Hans Schmidt of New York City (Schmidt and Olsson, 1916). Karl Schmidt later worked with the American Museum of Natural History and became a well known herpetologist.

[8] Both reside now in the library of PRI. HA-PRI, Ithaca, NY.

[9] This Cornell pennant survived the trip and now hangs at PRI.

[10] The dates refer to Grinnell's diary entries.

[11] The nick-name, Sister, was given to Smith because he came to Cornell from "religious Oberlin." (Schmidt and Olsson, 1916)

Their engine troubles were not over and it proved to be a constant source of irritation for them. Harris, however, was "not only a great geologist but a master mechanic as well," according to an entry in Grinnell's diary. As they were often moving in uncharted waters, running aground was another constant threat. One such occurrence was at Jones Wharf on the Patuxent River in Maryland:

> "As we landed, we hit a reef and you should have seen us pile off the boat. . . . We all pushed the boat with Prof. Harris at the bow and others astern. The boat finally started with a lunge as a wave helped raise the boat and our pushing almost ran the Prof. down; at least knocked him over and how we laughed and roared as he came up out of the water with his clothes on, his glasses wet and he sputtering and spitting out the salt water he had gargled. What a picture!" (July 3, 1914)

Rough seas, also, were not unknown on this voyage. A storm on July 4 continued with high waves the following day, and "Monty got so sick he felt sorry for the fish and fed them plentifully. We all played cards." Monty left the group on the evening of the 5th to go to Baltimore, while the voyage continued down the Bay toward Virginia. Here in the swamps of Tidewater, mosquitoes and other bugs became a real problem:

> "We anchored [up the Pamunkey River] alongside a huge marsh, with water moccasins, crawling with huge snapping turtles and swarming with mosquitoes as big as bats. Awful mosquitoes! We tried camphor-ice, Nyals, Skeeter-shoot and mosquito netting. They seemed to think we were throwing a party for them and everything we used was dessert and we were the main course. We were being eaten alive, but their buzzing in swarms sounded like bees swarming and drove us nutty. We couldn't sleep." (July 9, 1914)

At Petersburg, Virginia, this group of Northeasterners were told an unfamiliar version of a battle in the War between the States. An old Confederate veteran told them about how a Confederate lieutenant and eight hundred men drove Grant and fifteen thousand "Yank Rebels" as he called them, out of a fort that was known as "the Crater" after the Yankees mined it. "We were appreciative listeners," Grinnell commented. The story of the "Crater" was part of the Battle of Petersburg which resulted in a large loss of life, especially among black soldiers of the Union Army, and Harris' students heard about it from one who was there. Although history shows that Grant had very little to do with this battle, that probably made for a better story to tell those "yankee students."

Health and safety were constant concerns for the group, and although they took proper precautions, sometimes there were accidents. For example, on July 12, near Williamsburg, Virginia, Sunny was attempting to learn to swim while the others were collecting fossils along the beach, when Harris stepped on a serrated fish bone that went almost through his foot. Apparently they had a tough time pulling it out; Grinnell wrote in his diary, "It was a very painful ordeal and is very sore" (July 12, 1914). The "operation" must have been successful, for Grinnell made no further mention of the incident or of any complications as a result of them pulling out the bone.

On July 16, near City Point on the Appomatox River, the group met its first real danger. In threatening weather and an outgoing tide, they tried to take a shortcut across Tar Bay and became stuck in the mud:

> "We all tried to push, we sank into the soft mud, and the boat barely wiggled. We were frantic. Something had to be done quickly or the tide would leave us high and dry in the mud. We struggled back into the channel. No other boat would dare come into [sic] pull us out, and no sign of civilization anywhere. Then the lightning flashed and thunder rolled.
>
> "Hans and Park went out in *Pecky* [*Pecten*, the dinghy] to sound for deeper water. It was several hundred feet to our left. But how could we get there in that soft, footless mud? The harder we pushed on the boat, the further we sank into the mud. We were desperate! The Prof. came to the rescue as usual. He directed us to take the 80 lb. anchor with its long heavy flukes out to the end of our 100 ft. of rope. We rowed it out and two fellows, Hans and Ollie, stood on it in the mud while the rest of us on the boat heaved on the rope. . ..[T]hen by moving the anchor out three times more and pulling up to it three times, we finally got into deeper water and the boat floated." (July 16, 1914)

As soon as the boat was in a safe mooring near Coggin Point, the storm abated, the sun came out, and they continued their trip to the end of Tar Bay to check on a location of Miocene sediments:

> "This must have been a Miocene burial ground, for fossils were thick as gravel stones in a gravel pit. We had collected but a few minutes when Ollie found a new species of cardia [sic]. Soon we found two new pectens that we had not found before. One of these, too, was a new species that had never been named. I found what I prized highly. It was the largest Ecphora of this or any other trip. Prof. Harris found a large one many years ago, and it is now in the Smithsonian Institution, as the largest one known. But this beat that one. It is a whopper nearly as big around as my head. The Prof. says the one he found is the size of a big fist. This one is four times as big." (July 16, 1914).

Eventually they had to begin to retrace their path back toward Ithaca, and the diarist experienced his first and only bout of seasickness. His remedy will probably never replace dramamine. It was Grinnell's time to prepare breakfast:

> "There was a heavy sea running. The wind was strong, and the tide was going out. The boat tugged at the anchor rope and the cross wind chopped the Ecphora up and down in a rotary motion. Either that motion or the fumes of the kerosene stove on which I was cooking breakfast gave me a funny feeling in my stomach, and I felt I must be getting seasick, although I had never been before. . . . I had on only sailor pants, so I dropped them off, and rushed up on deck and dove off the top of the boat on the leeward side. A solid mass of slimy, stinging jelly fish or portuguese [sic] men-of-war had collected there in the protection of the boat away from the wind. I smashed right into them. They were all over my naked body and in my hair. I dove down through them, but then dared not come up, so swam around and under the front of the boat, and came up on the windy side. When I had clambered aboard, I was no longer threatened with seasickness. But I was almost stung to death by the jelly fishes, or more properly stung to life, for they certainly revived me. After finishing the preparation of breakfast, I turned off the kerosene and swam ashore." (July 22, 1914).

As they were going north through the Delaware-Chesapeake Canal, Hans invented a new sport: he would dive off *Ecphora* and catch the trailing *Pecky* as it came by. But if he missed the dinghy, he had to swim to shore, run along the towpath, then dive in ahead of the boat and swim out to catch it. Before long others were trying this, and on one such venture, Sister, who only a week or so before was trying to learn to swim, Hans, and Nellie all missed *Pecky* and had to run about one hundred fifty yards to catch *Ecphora*. They all dove into the canal to swim to the boat and Hans and Nellie were hauled on board, but Sister, who was very much out of breath from running, missed the pickup and sank:

> "So we passed him by and he went down to the bottom of the canal, probably about ten feet deep. Hans quickly dove overboard and I threw a life preserver about where he would come up. Before Hans got to him he came up and sank a second time, but he did not see the life preserver. Sunny turned the boat around, and I dove in to help find Sister. When he [Sister] went down the second time, his feet hit bottom and he kicked so hard that he came up quickly and Hans grabbed hold of him. About that time I got in the way of the boat and almost got run over as I scraped alongside and just missed the propeller as it went by, then *Pecky* bumped into me and I held on to her and helped Hans tow an exhausted "Sister" Smith to *Pecky* and then to the *Ecphora*. But he was all right as soon as he got his wind." (July 22, 1914).

The following day they saw the body of a young boy, who had not been as lucky as Sister, being pulled from the canal.

Although their primary interests were paleontology and stratigraphy, the return trip beneath the Palisades along the Hudson River brought out the poet in Grinnell:

> "This was really the most beautiful scenery we had yet seen. The Palisades are beautiful colums [sic] and towering cliffs with deeply carved towers, all dotted with green shrubbery, and all high above the majestic Hudson. The intrusive columns of the Palisades make a rare picture. The highlands, too, with their rounded domes of Archaean rock and huge whale backs, bumped up here and humped up there with a beautiful valley of green forest in between. There were many huge castle-like homes perched up on the heights overlooking the river, and as we looked up at them they were seemingly hanging from the sky, while others were clinging, perched precariously on the edge of a cliff or a steep hillside. It all made an enchanting picture." (July 24, 1914).

It was one in the morning on July 27th when they reached the lock into Cayuga Lake, and the lock-tender had gone to bed. But by this time they were all experienced "lock-tenders", and they simply let themselves through. They had to awaken the operator of the last railroad bridge to let them pass, however, paying him ten cents for his trouble. At last, they were on "the broad bosom of Cayuga Lake" by 1:20 A.M. After an all-night run down the lake, Hans dove over the side for a morning swim and nearly froze. Cayuga Lake was much colder than the Chesapeake.

Grinnell summed up the voyage:

> "Thus ended the epic trip of the great little ship, the *Ecphora*, and her baby the *Pecten*, which had bobbed along behind us for many a league of knots. This had been a great experience for all of us, and a grand cruise in more ways than one. We all felt it had been eminently successful, as we had found many wonderful specimens and discovered several new species for Professor Harris and his department to classify and name. We had had a lot of fun and we all loved and respected one another. It was a grand bunch of fellows, but more than that for dear Professor Harris: we all felt that he was super, and the finest and grandest man it had ever been our privilege to be associated with. May he live long and ever happily in order that he may fulfill a great contribution to Geology and particularly to Paleontology. His name and his fame will echo down through to ages, long after the rest of this motley crew are forgotten." (July 28, 1914).

This journey, like all the others, was more than just swimming in the canals and fighting off jelly fish; there was a serious side as well. The people who accompanied Harris on these boat trips were privileged to see a master paleontologist do field work and thereby learn their craft, and these extended trips built a bond between student and teacher that literally lasted a lifetime. And, of course, there was the resulting science, *i.e.*, the descriptions by Olsson (1914) of some of the material the group collected on this journey to the Coastal Plain.

In reading Grinnell's description of the trip, one is led to wonder whether today's students are missing something when in less time than it took them to reach the end of Cayuga Lake we can cross a continent. How much more detail can be seen in the Palisades from a boat drifting by them at six miles per hour than from a car driving across the top at sixty miles per hour, or a plane flying over them at six hundred miles per hour!

The following year, 1915, there were some questions from the University administration to Ries concerning Harris' summer activities. President Schurman wrote:

> "As you [Ries] are perhaps aware, Professor Harris, up to 1912, was professor on half time at a salary of $1500. In 1912, after Professor Tarr's death, he was asked to give full time for the year 1912–13 at a salary of $3000 for the year. At the expiration of that year, he was re-appointed professor for one year for $3000, and in the following year (May 11, 1914), he was again appointed professor for one year at $3000.
>
> "I should like to know now whether the University needs the full time of Professor Harris, or whether the University could revert to the arrangement, which was in existence for many years, under which he gave the University half his time. . . .
>
> "If Professor Harris is not to be absent from the University half of his time, does he desire to be absent for a portion of his time?. . . . I should think it advisable if this arrangement is to be continued, that a resolution should be adopted by the Trustees authorizing it generally and making a fair adjustment of the salary.
>
> "Professor Harris has I know been very much interested in summer work in paleontology. . . . If, however, students are taken away in the summer and given credit for their work, would it not be fair that they should pay a fee? And if Professor Harris himself gives time in the summer to the instruction of students, it would seem fair that he also should receive some compensation. I hasten to add that it may be impossible to authorize the summer course in paleontology, if the receipts therefrom are insufficient to cover all the expenses incurred in connection with it.
>
> "I must add for your information that I am not at all certain that the Trustees would or could grant professors in the University leave of absence for six weeks or so during the regular academic year on condition that they give a corresponding period of time to summer instruction. That, however, is a question which must be settled by the Trustees. I only note it here in order that you [Ries] may not take any solution for granted."[12]

After some discussion with Ries, Harris replied:

> "Upon due reflection re matter discussed yesterday I believe the interests of all concerned demand that what work over and above the regular university year is undertaken by members of this branch of the department be limited entirely to private enterprise, thus eliminating all misunderstandings as to expense, tuition, credit, and serious obligations that may at some time be almost impossible to fill. It costs time, money for fuel, repairs, upkeep, interest on investments, insurance, to say nothing of worry and risks at least $1000 to carry out a successful cruiser expedition along the East Coastal regions, and what little would be returned by tuition at $30 apiece [*sic*] would amount to very little towards the whole. Of course it would be a little but would weigh nothing in assuming such responsibilities to be carried out every year without fail. Personally I hope to be able to carry out this work as planned for at least 10 years. But the expenses are too great for me to promise certain extensive programs definitely every year."[13]

Regardless of the cost, however, Harris took some students on *Ecphora* down to the coast again, going through Dismal Swamp Canal to Albemarle Sound, North Carolina and the Neuse River; eventually covering over 3000 miles between June 7 and August 11, 1915. But before embarking on the second major voyage with *Ecphora*, Harris had to do some modifications:

> "Ax [Axel Olsson] tells me you have bought the Ecphora an engine and a good one, which is certainly good news . . ."[14]

The four cylinder, 30 horsepower Loew Victor engine, built in Chicago[15], was purchased from Bruns, Kimball & Company, of New York City.[16]

The students on this trip included E. R.(Sister) Smith and Karl P. (Hans) Schmidt (both back for a second summer); Charles. P. (Chuck) Alexander, the entomologist; Bayard Taylor; James D. (Tommy) Thompson, Jr. (graduate student '14–'16), who was the "chef as distinguished from cook."; and Axel A. Olsson (A.B.'13)[17]. Taylor did not graduate from the Geology Department. Schmidt was considered the engineer and vertebrate zoologist; Smith was "commissioner of business affairs"; and Olsson was the chief cook, electrician and paleontologist (Schmidt and Olsson, 1916). This voyage resulted in the collection of more than sixty boxes and barrels of Miocene fossils and rock samples.

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[12] Jacob Schurman to Heinrich Ries, May 28, 1915. Heinrich Ries Papers, 14/15/691, Box 1, File 1-22. RMC-KL, Cornell.

[13] Gilbert D. Harris to Heinrich Ries, June 1, 1915. Heinrich Ries Papers, 14/15/691, Box 1, File 1-22. RMC-KL, Cornell.

[14] Karl P. Schmidt to Gilbert D. Harris, March 5, 1915. HA-PRI, Ithaca, NY.

[15] Instruction booklet from Loew Victor Company. HA-PRI, Ithaca, NY.

[16] M. C. Kimball to Gilbert D. Harris, March 16, 1915. HA-PRI, Ithaca, NY.

[17] Axel A. Olsson (1889–1977), a student of Harris', worked for various oil companies, including Sinclair. He was a founding member of PRI and first President, and was present at the laying of the corner stone on June 28, 1932 at the Dearborn Place facility (Moore, D. R., 1978).

Although there is no diary record of this trip, an article by Schmidt and Olsson in *Power Boating* magazine following the journey gives a wonderful account of the trip and provides an inside look at their experiences. The following description comes from that article.

The group left Ithaca about 11 A.M. on June 7 giving the Ithaca Lighthouse the "Cornell yell", and entered the canal system five hours later. Mechanical problems were not unknown on this trip either, even before they cleared the New York canal system. Just below Little Falls the reverse gear broke off at the collar and it took four day to get it repaired. But they were in the Hudson River by June 15. They took a quick stop to inspect, and admire, the museum at Princeton University before continuing down the Delaware Canal system, and gaining a healthy respect for the New Jersey mosquitos. At least two of the *enfants*, as Alexander, Thompson, and Taylor were known by the rest of the party, discovered the joys of seasickness shortly after *Ecphora* entered Chesapeake Bay. It was in this area that the serious collecting began, although the group was also impressed with the Cretaceous fossils they saw piled along the banks of the Delaware and Chesapeake Canal:

> "Few places that we saw on our journey offered a more desirable field for study than the 13 miles of this one-hundred-year old canal, so that we envied the lock keepers their magnificent opportunity, of which they doubtless never dreamed." (Schmidt and Olsson, 1916, p. 19).

At Langley's Bluff, a small anchorage south of Cedar Point, where they took shelter from the wind and high waves, they did their first real collecting. The wind did not let up and Thompson and Alexander became so seasick that they were put ashore to walk to the next anchorage, without their shoes, of course. They took a side trip up the Potomac to Washington, D. C. where Harris had worked about 20 years earlier. It was here that the trip nearly ended in disaster. Just before taking a shore excursion, someone left the fuel tank valve open and they returned to find about 20 gallons of gasoline in the bilge. After cleaning up the spilled fuel, they proceeded back down the Potomac collecting at such famous localities as Aquia Creek, Potomac Creek, and Pope's Creek, all yielding many boxes of fossils and valuable first-hand experience for this group of young geologists.

At the mouth of the river the winds and waves were still high and they took refuge at the village of Lewisetta and explored the art of dealing with a boat stuck on a mud flat. They should have conferred with those from the 1914 trip, who had a similar experience. But each learned on their own. The procedure seemed simple enough: when the boat ran aground, or "snotting it" as they called it, all hands but the captain shed their trousers and went overboard to lighten the boat. Then she usually floated free or could be pushed back into deeper water. But when the water was filled with jelly fish whose nettle-like sting could persist for many hours, the procedure became more complicated and painful, if no less necessary.

While in the harbor at Hampton Roads, Virginia, the group saw several interned German cruisers, a grim reminder of the realities of the world in 1915. Two of the group were to come face to face with these realities a little later in the trip. They travelled near Roanoke Island, where Sir Walter Raleigh had established his ill-fated colony some 330 years earlier. Eventually on July 7, 30 days after leaving Ithaca, the hardy band of travelers had reached their destination, New Bern, North Carolina and the junction of the Neuse and Trent Rivers. Here they split into three collecting parties and each went off in search of fossils; some by rail south to Wilmington and north to the Chowan and Meherrin Rivers. On July 15, the three who remained with the boat started north and the rest joined them along the way, with some interesting tales to relate.

Although Schmidt and Olsson say little about their adventures in their article, probably because Olsson was directly involved, newspapers from Virginia and Baltimore to Ithaca carried the story. *The Ithaca Journal* of August 30, 1915 does give some indication of their activities. It seems that on one occasion, Olsson and Taylor were near Harrellsville[18], a little town in North Carolina along the Chowan River, checking stream beds, hillsides, back yards and gardens, and other out-of-the-way places, for fossils. The local inhabitants thought their behavior rather suspicious—particularly as the nation was almost at war. The sheriff, who was 15 miles away, sent word that the village doctor, storekeeper, and hotel keeper should act as a "Committee of Investigation." The two students were picked up and taken before this committee. When questioned, their claim to be just collecting rocks, brought laughter to the captors. The villagers knew these strange people must be either spies or crazy, for everyone knew the rocks in that part of the country were useless. Eventually, after producing some shipping receipts for samples they had shipped back to Cornell, the pair convinced the townspeople they were telling the truth and that they were not German spies. A very disappointed posse released their prisoners, but were happy that their city was in no danger from German submarines.

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[18] The Suffolk newspaper article named the town "Haroldsville".

A local paper in Suffolk, Virginia, got wind of the story and made much of the fact that their neighbors to the south had taken Cornell geologists for German spies. Then it made the editorial page of the *Baltimore News* which compared it to a similar incident when a local group went out to investigate the "suspicious" behavior of a Harvard geology professor out in the Bad Lands of Dakota. As the group was about to surround him, thinking they were a band of outlaws, the professor took flight and led the group on a wild, 40 mile chase through the hills before he was "captured." And now another case had occurred in "far-off but sociologically wholly different North Carolina." Putting the two incidents together, the editorial suggested it was clearly the fault of the scientists:

> "The occurrence of two such distinctly differentiated yet analogous cases acquits the Bad Lands of gross ignorance of inhospitality. It puts squarely upon the geologist the obligation to wear some mark which will distinguish him from the undesirable. Clearly the symptoms of his vocation are dangerously confusing."[19]

In another town things got more serious when a farmer fired a shotgun at Thompson. It seems that Thompson had been collecting in a nearby quarry and was walking back toward the boat with his arms full of fossils. He heard someone tell him to stop, but assumed the command was meant for someone else and seeing no reason to stop, he walked on, until the man behind the voice fired his shotgun. Apparently, someone had been stealing watermelons from a field near the quarry, and when the farmer saw Thompson with his arms full, he felt he had caught the thief.

The return journey was made over the roughest water of the entire trip and, according to Schmidt and Olsson, it included battling some of the largest mosquitoes ever seen. In 1914 the run from Newport News, Virginia to Ithaca had taken eight and a half days, but various mechanical problems did not allow them to break that record. Ominous sounds and propeller shaft vibration developed as the engine was run at slow speeds. An inspection showed no obvious problem or cause. At other times, all went well, and once they ran the engine for 22 hours straight with no difficulty. Their trip north provided some memorable times and sights:

> "What words can describe the feelings of the pilot, as he watched the slow rise of the constellations in front of him, and came to anchor safely in the Elk river, just inside of Turkey point, as the moon set blood red in the west." (Schmidt and Olsson, 1916, p. 21).

The next morning they discovered the propeller had fallen off.

They found two men with a boat who were willing to tow *Ecphora* to Havre de Grace on the Susquehanna River where they found an old foundryman who would cast them a new one. Unfortunately the blades of the only mold he had were too large, but with some grinding work, they managed to limp into Chesapeake City for a proper replacement, only to have the vibration return when they restarted the journey. This time the shaft had to be replaced, but the rudder was in the way, which would have meant digging a three foot hole in the ". . . doubtful smelling mud of the Brandywine, racing to get it done before the return of the tide, . . ." But Harris came to the rescue with a simple idea. They simply turned the rudder sideways and drilled a 1.5 inch hole in it right over the shaft and slipped in the new shaft in short order.

But they continued to have engine and other troubles all the way back to Ithaca, including stripping all the gears in the magneto, and finding a bridge down across the canal at Utica. By removing all awnings, they were able to slip under the bridge, much to the disappointment of the local crowd. They finally reached Ithaca on the afternoon of August 11 to the cheers and congratulations of friends and relations. The journey of 3000 miles had produced about 60 boxes for fossils, over 5000 pounds. Some of the fossils were described by Olsson (1916).

For the students:

> "The value of the trip to us-students of science-could scarcely be estimated. Professor Harris' attitude toward his students seems best expressed in the words of his predecessor at Cornell, Charles Frederick Hartt, in his account of the Morgan Expedition[20]: 'If to discover a new Carboniferous Fauna will repay a journey to Brazil, of how much greater importance is the discovery of a new Naturalist?'" (Schmidt and Olsson, 1916, p. 46).

As had been outlined in Schurman's letter in May, 1915, it appears Harris' summer field activity was running afoul of university bureaucracy. That autumn, Harris wrote to Ries:

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[19] "It Might Happen Anywhere" *Baltimore News*, July 25, 1915, page unknown.

[20] A Cornell expedition to Brazil funded mostly by Colonel Edwin B. Morgan of Aurora, New York in 1870. The rest of Hartt's quotation is, "Had the expedition produced no other results than to have added four new men to science, I should have considered time and money amply well spent." "The Morgan Expedition, 1870–71, *Bulletin of the Cornell University: Science*, v. i, no. 1, p. 4)

> "If another expedition to the south is altogether too expensive for my private funds, I can perhaps for one year equally well continue a little piece of delayed work in northwestern Pennsylvania that I commenced three years ago; work that would imply topographic, stratigraphic, paleontologic, and physiographic research of various degrees of advancement."[21]

Ries replied quoting from Schurman's letter from the previous spring about the Trustees probably not approving the arrangement of replacing regular academic term work with summer activities for all professors, and thereby eliminating it for the one. Ries closed with:

> "He [Schurman] believed that if a department is to run summer work, it should be treated as a separate matter, and separate compensation should be allowed for it. And if such compensation were allowed, it seemed but fair to the President that the students taking this summer work should pay a tuition fee.
>
> "As you were not willing to agree to the latter, I could not agree to ask the Trustees for an appropriation for the summer course, your final decision was to run this as a private matter."[22]

Thus the victim of the University bureaucracy and rising costs, there is no record of any further extended boat trips by Harris after 1915. He did continue using *Ecphora* for short trips on the lake, but he was already looking to the future, for in his Annual Report to Ries, head of the department, for 1919–1920, Harris said:

> "Several excursions were given on the lake by boat last fall and will be this spring [1920], but I find for small classes that a Ford is very desirable. In the University of Texas I understand a large excursion truck is owned by the department for excursion work."[23]

Ecphora continued to make various field trips until about 1920[24] (Palmer, 1953a), when Harris sold her to A. C. (Dave) Davis, a Cornell engineering professor. She must have stayed in the Ithaca area, for by 1964 *Ecphora* was owned by Peter Paul Kellogg, a Cornell ornithologist who used her for his exploration and research. When last heard of, according to Kellogg, she had been taken to Florida, but her current location or condition is unknown.[25]

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[21] G. D. Harris to Heinrich Ries, September 22, 1915. Heinrich Ries Papers, 14/15/691, Box 1, File 1-22. RMC-KL, Cornell.

[22] Heinrich Ries to G. D. Harris, September 25, 1915. Heinrich Ries Papers, 14/15/691, Box 1, File 1-22. RMC-KL, Cornell.

[23] Page 2; G. D. Harris Annual Report for 1919–1920 submitted to Heinrich Ries, April 15, 1920. Heinrich Ries Papers, 14/15/691, Box 1, File 1-85. RMC-KL, Cornell.

[24] In a personal communication July 22, 1983, Katherine Palmer indicated that 1918 was the last major *Ecphora* field trip.

[25] History of the *Ecphora* prepared by Peter Paul Kellogg, June 10, 1964. Copy in HA-PRI, Ithaca, NY.

CHAPTER 5. THE LOUISIANA SURVEY

Although it is not known exactly how or through whom Harris secured the appointment in Louisiana, there is little doubt that during his various trips to Arkansas and Texas, and with his work near the border between northern Louisiana and Arkansas while doing stratigraphic mapping for the Arkansas Geological Survey, he must have come in contact with influential people in the Louisiana government. With those connections plus his reputation as a Tertiary paleontologist, Harris was appointed "Geologist in Charge" for the Geological and Agricultural Survey of Louisiana in 1899. Pope (1988) states that he followed William W. Clendenin, who had led the survey from 1894–1897. The original state survey, the Topographical and Geological Survey of Louisiana, was organized in 1869 after the recommendation of a special committee in 1856:

> ". . . a geological and scientific survey of the State of Louisiana, is under all the circumstances, much to be desired, and that it should be judiciously, not too rapidly, prosecuted." (Riddell *et al.*, 1856, p. 6)

This original organization lasted until 1872 when funding was withdrawn.

A new Survey started again in 1891–92 as the Geological and Agricultural Survey of Louisiana under the direction of Dr. Otto Lerch who came to Louisiana from the Texas Survey. Each of these Surveys was associated with Louisiana State University and Agricultural and Mechanical College (LSU) in Baton Rouge, and Survey directors were expected to serve on the faculty of LSU as well. But funding ended again in the very year it was commissioned. In 1894, William Clendenin assumed the leadership of the Survey, lasting in this role until 1897. According to the letter of transmittal for the 1896 report, Clendenin devoted ". . . October to March . . . to LSU . . . and the rest of the time to field work of the survey." (Clendenin, 1896, p. 163). Thus, a pattern was established for the Survey director to be "part-time," which Harris continued when he spent part of his year in Louisiana and the rest at Cornell.

When Harris was appointed in late 1898, there had been no survey work for two years. At this time the geological survey activity came under the political arm of the State Experiment Stations, which had Dr. William C. Stubbs as their Director. Harris, like Lerch before him, was not on the LSU faculty. That very first year, 1899, A. C. Veatch (age 21) worked as Harris' assistant, a position he held for several years. Veatch was the first of several Cornell students, as well as some from LSU, who worked with Harris in Louisiana. In his letter of transmission to the Governor for the 1899 report, Stubbs extolled the quality of the work that team did during their first year:

> "Since our last report of the Geological and Agricultural Survey, a complete change has taken place in the personnel of the survey. Prof. W. W. Clendenin, who performed the duties of Professor of Mineralogy and Geology in the Louisiana State University and A. and M. College, and geologist for the stations, has severed his connections with both institutions by resignation, and taken charge of Blees' Military Academy, at Macon, Mo.
>
> "Upon his resignation arrangements were made with Prof. Gilbert D. Harris, Ph.B.[1], of Cornell University, who is the recognized authority of this country in Tertiary geology, by which he was to conduct the survey under our direction and publish annually a report of his work. He gives considerable time to the actual field work and writes and superintends the publication of his reports. Mr. A. C. Veatch has been selected as his assistant and gives his entire time to the field and office work of the survey. Mr. Veatch is an acknowledged authority upon Quarternary [*sic*] geology, and with his assistance we feel satisfied that the entire State, which consists almost exclusively of tertiary [*sic*] and quarternary [*sic*] formations, will be correctly and fully reported. These two gentlemen have persistently followed their work through freezes and sunshine, over intolerable roads, impelled by an enthusiasm known only to lovers of science. How well they have accomplished their work, the present volume will testify." (Harris and Veatch, 1899, p. 4)

In his own letter of transmittal to Stubbs, Harris outlined their activities and had some words of praise for Veatch:

> "Mr. A. C. Veatch acting as assistant geologist, commenced field work November 1st, 1898, and studied the distribution of the soils of Caddo and Bossier parishes until my arrival in the State, December 23rd. Thereafter we worked for the most part together in De Soto, Sabine, Natchitoches, Grant, Winn, Caldwell and Ouachita parishes.
>
> "After my departure from the State, the last of March [1899], Mr. Veatch continued work in the northern tier of parishes between Ouachita river and Red river until requested by you to visit the Five Islands and the Sulphur region of the southwestern part of the State. This done, we worked on the report herewith transmitted from midsummer to late autumn, when he again took the field and I saw to the completion of the report.
>
> "I gladly take this opportunity to inform you that Mr. Veatch has in all his connections with this survey, shown

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[1] Bachelor of Philosophy.

> himself a most capable and energetic assistant; and it is to his untiring zeal, and your [Stubbs] never failing and well directed support that such success as the survey has been able to attain is largely due.
>
> "Most respectively submitted,
> GILBERT D. HARRIS,
> Geologist-in-Charge.
> Cornell University, Ithaca, New York,
> November 25, 1899."
> (Harris and Veatch, 1899, p. 6)

Harris was always mindful of his own strengths and weaknesses with regard to geological work, and this first report of 1899 illustrates that quite well. For the necessary work that was outside his expertise, he involved other colleagues; Heinrich Ries of Cornell did the analysis of clay samples that Harris collected (Ries, 1899), and Arthur Hollick of Columbia did the fossil plant identification (Hollick, 1899). And even though the section on the Cretaceous fossils is published under his name, in the introductory remarks, Harris gave full credit for the identification of these fossils to T. W. Stanton, a former co-worker at U.S.G.S. Pope (1988, p. 188) describes the results of the 1899 activities as, "By far the most productive of the early surveys."

One very important aspect of the reports of 1899 can be found in Veatch's report on "The Five Islands" (Veatch, 1899) in which he maps and describes salt domes in the Parishes of Iberia and St. Mary. Although at this point in time, salt was the attraction, not oil, it was Veatch's careful mapping, especially of Petite Anse Island, that revealed these important structures. Veatch mentions the existence of both oil and gas associated with the salt deposits:

> "In hole number 10 [on Belle Isle] gas was struck at a depth of 120 feet in sufficient quantities to throw sand all over the derrick. It is now bubbling out the hole where it can be easily collected and ignited. A small amount of gas and oil was struck in hole number 4." (Veatch, 1899, pp. 224–225).

The cross section in figure 6 in Veatch's paper is a classic salt dome structure showing holes 4 and 10 on the flank. Further, Veatch concludes that the, ". . . dome shape is due to uplift and not erosion." (1899, p.228). He found similar structures on the other islands as well.

The work of Harris and Veatch put to rest the current popular belief in a Cretaceous "backbone" which was supposed to extend through the Five Islands area and connect with structures running up through Arkansas:

> "Our observations go to show that whatever folding and faulting has been the cause of bringing the underlying Cretaceous strata to day, has been in the northeast-southwest direction, roughly parallel in fact to the northwestern shore line of the old Mississippi embayment in Eocene Tertiary time.
>
> "The shallow depth at which rocks supposed to be of this series [the Cretaceous age backbone] have been struck . . . [in various wells, and] . . . the great depth of the Shreveport well (1,100 ft.) with no record of Midway beds [of lower Tertiary age] or Cretaceous limestones though nearly in line with the so-called axis or "back-bone", [as well as] the various dips observed in the limestones at various exposures with but one exception-the St. Landry outcrops-all indicate northeast-southwest local folds parallel to old shore lines rather than a mountain chain at right angles to the same, or in a northwest-southeast direction." (Harris and Veatch, 1899, Section II, p. 62)

When Harris began his work in Louisiana in 1899, the area was poorly mapped, and in many areas he and his crew had to create their own base maps before doing their geological work. There is a section in the 1899 report in which Harris addresses, "The Establishment of Meridian Lines." He described the difficulties of doing land surveying using only a "magnetic needle" for determining direction:

> "Different men with different instruments at different times, have naturally, as we well know, come to very different conclusions regarding the location of many corners and boundary lines." (Harris, 1899c, p. 312).

Throughout his work in Louisiana, Harris always tried to maintain the most accurate readings possible with his surveying work which is well illustrated in his letters. Apparently in his quest for accuracy, Harris sent some of his equipment to Washington, D.C. for testing:

> "Your compass needle to your transit requires a correction of +8' for east declination and −8' for west declination, In the official communication this corr'n [*sic*] will probably not be changed by more than 1'"[2]

He even had his steel tape measured and received a "Certificate of Verification—National Bureau of Standards" which did a test on his 100′ steel tape; ". . . with 10 lbs of tension, off +0.03" in 50′ and +0.03" in 100′."[3]

The accuracy of the surveying work of Harris and his various teams, especially that of Veatch, was remarkable; almost 60 years later, no one had improved upon it:

> "The cartographic history of the Sabine River is reviewed by Veatch (1902, pp. 107–111) whose personal work in mapping the course of the stream in 1900 (published in 1902, pls. 32–36) is without peer. . . . The writer would be remiss not to add that the course of the Sabine River

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[2] L. A. Bauer, Coast and Geodetic Survey office in Washington, D.C., to Gilbert D. Harris, December 22, 1902. HA-PRI, Ithaca, NY.

[3] National Bureau of Standards [signature illegible] to Prof. G. D. Harris, State Geologist, Louisiana, December 23. 1902. HA-PRI, Ithaca, NY.

> mapped by Veatch in 1902 was also done with much topographic skill and fidelity which is substantiated by aerial photographs and the fact that the outcrops described along the Sabine River can be accurately located today [1960] from the 1902 map (figs. 2 and 3). [Parentheticals in the original.] (Anderson, H. V., 1960, pp. 18,19).

Harris continued to use Veatch and other students as his assistants with the Louisiana work, even though Veatch was attracted to the U.S.G.S. in 1902 in a full-time capacity. Often the same people would work with him in the Helderberg Field Camp during the summer and then go south with him in the winter (Plate 3). John L. Rich described his association with Harris:

> ". . . and in the summer of 1905 [Harris] led a party consisting of Whitney,[4] Reinecke,[5] and Rich, together with three students from Louisiana State University, in a project for preparing a map and geological report of the Winnfield sheet, Winn Parish, Louisiana. During that summer, the controls for the map were established. During the following winter [1906], Whitney, Rich and E. B. Hopkins completed the contouring of the sheet while Harris made the geological studies. Needless to say, all this was extremely valuable training for the young geologists concerned."[6]

Their work became part of the 1907 report (Harris, 1907a,b) and all their names, including the LSU students, appear at the bottom of the two maps.

In the report on the Winnfield Sheet (Harris, 1907a), Harris concludes that faulting and folding were not responsible for the development of large dome-like structures they were seeing:

> "The longer we study these peculiar structures [salt domes] the more convinced are we that although they may be located along lines of weakness, faults, or fractured anticlines, they are not to any great extent due to tangential, mountain-making forces, not to volcanic upheavals, nor igneous plugs, as has recently been suggested, but to the slowly-acting, little understood, concretion-forming forces as well as the power of crystallization. Hot saline or calcareous solutions, coming from earlier Mesozoic or later Paleozoic beds beneath, rising perhaps by hydrostatic pressure alone, may very readily, upon reaching a level where the pressure is somewhat relieved and the temperature decreased, deposit some of their mineral contents." (Harris, 1907a, p. 9).

This was the core of Harris' theory of salt dome formation and subsequent uplift with the major force coming from salt crystallization as the rising saline waters cooled. Experimental work by Harris on salt crystallization appeared to support his hypothesis of, ". . . the power of growing crystals." (Harris, 1908, p. 134). While this idea was gradually replaced by the concept of diapiric rise of the salt masses (due to differential density of the salt and overlying sediments), as late as mid-century, some workers in the field were re-examining Harris' idea (Willis, 1948).

Although Harris and Veatch made some of the early detailed descriptions of these domed structures in Louisiana, the commercial connection between the domes and petroleum came from Captain A. F. Lucas and his work with the Spindle Top, Texas, oil field. In 1897, Lucas had been working in the Five Islands region and discovered the salt deposits on Belle Isle and Grand Côte. At these locations Lucas recognized that while these deposits were limited in horizontal extent, they were extensive in the vertical dimension. Lucas moved on to Texas where he discovered the first of the major oil fields on a dome structure, and Harris gave full credit to Lucas:

> "More and more work was being done on the salines of north Louisiana in 1900 and 1901, when suddenly the commercial and geological worlds were astonished at the marvelous results of Capt. Lucas' boring on a slight rise of ground known as "Spindle Top," three miles southward from Beaumont, Texas. Oil at this place seemed to indicate that perhaps, although no salt was known at Spindle top, there was some relationship betweeen [*sic*] oil and salt mounds and low domes and salines. . . . January 10, 1901 [date of Lucas' first oil strike, a "gusher"], may well be considered the date of the commencement of our education regarding a new type of geological phenomena—we refer to the *origin and method of development of local dome structure*." [Emphasis in the original.] (Harris, 1908, p. 121[7]).

Thus, this was an exciting time in Louisiana as Harris was beginning his tenure as Geologist-in-Charge, for the oil industry was gaining momentum. In his letter of transmission for the 1902 report, Stubbs described the situation this way:

> "Since our last report a wonderful interest has been created in the geology of Louisiana by virtue of the discovery of oil in this State and Texas. . . .
>
> "Numerous gushers at Beaumont, Texas have excited persons in all parts of the State to action. Many wells have been bored in various parts of the State, and numerous companies have been formed for exploiting the State's wealth in this great fuel and illuminant.
>
> "Some few efforts have been successful; many have failed.

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[4] Francis Luther Whitney (A.B.'06, M.S.'11; Ph.D.'28), later a Professor of Geology and Paleontology at the University of Texas in Austin.

[5] Leopold Reinecke (1884–1935), a South African who was at Cornell (M.S.'09) and studied with Harris. Completed his Ph.D. at Yale in 1914. He worked with the Geological Survey of Canada, with Sinclair Oil company and as an economic geologist in South Africa (Collins, 1937; Nel and Krahmann, 1937).

[6] John L. Rich to Axel A. Olsson, February 21, 1953. HA-PRI, Ithaca, NY.

[7] See also Harris, 1912b.

> In this report will be found a full discussion of the oil conditions of this State, and it is hoped that the facts given will deter companies from expending large sums of money in the vain hope of obtaining oils in unfavorable localities where the so-called oil experts have pronounced an abundance of this greasy fluid. A knowledge of the geology of a section is often of valuable aid in determining where not to bore." (Harris *et al.*, 1902, pp. iv–v).

In reality though, only one portion of the 1902 report, Special Report 8 "Oil in Louisiana" which Harris wrote, dealt directly with the oil geology. It is interesting to note that this report provided the drilling results of several wells, including complete well logs giving descriptions of the various layers and at what depth the strata were encountered (Harris *et al.*, 1902, pp. 261–275). This was Harris' first direct encounter with an industry that was to dominate his non-academic life for many years.

A measure of the general excitement engendered by these discoveries can be judged from a letter sent to Stubbs in 1902, who, in turn, sent a copy to Harris. A Mr. C. M. Hicks, Treasurer, Sicily Island Oil Company, Wisner, Louisiana, was happy to hear that Stubbs was:

> ". . . inogorating [*sic*] a Geological Survey in the La. Parishes. We will be vary [*sic*] glad to give any information or assistance in our power to aid this highly appreciative enterprise. I hope your geologist are [*sic*] ready to take up (our Franklin Parish) the work that they will come direct to Wisner [Louisiana] as we will meet them if they will wire us. . . . We would be pleased to have them with us at an early date as there has been one oil well sunk and arrangements are being made to put one down an other [*sic*] one on Sicily Island. We have had no good results so far."[8]

An article in a local New Orleans paper, *Times Democrat*, commenting on some cooperative efforts that Stubbs had mentioned also generated some letters in which the writers were happy to see that Stubbs:

> ". . . has secured the co-operation of the Agricultural Bureau at Washington, in securing the services of an expert to examine the resources of our state, and that one of the gentleman is an expert in examining oil lands. . . . [ask for him to] examine some lands we have at Lafayette, La. at the LaFayette Refinery, for the purpose of ascertaining whether these lands are oil bearing. In this connection, we would explain that we have sunk at that point three 8" [diameter] artesian wells for the purpose of supplying the refinery with the necessary amount of water. These wells are connected to a powerful air compressor and when ever the full force of the air compressor is confined to one of these wells, the oil flows out with the water. This leads us to beleieve [*sic*] that there may be oil in paying quantities, and of course we would like to have an examination made."[9]

Despite all the rising interest, the first successful wells in northern Louisiana were not drilled until 1904, which in turn led to the development of the Caddo field which hit its maximum production in 1913 (Powers, 1920b). Veatch (1906b) had described the geology of this area in his massive groundwater report for the U.S.G.S.

Based upon his earlier experiences with the U.S.G.S., Harris was familiar with "cooperative" operations between the federal and state surveys, and his Louisiana Survey was asked for its cooperation. One such request occurred in 1903 when Veatch was working with the U.S.G.S. Harris was in correspondence with F. H. Newell, who said, "Mr. Veatch is now working for us in southern Arkansas and northern Louisiana, . . ."[10] Then he went on to ask Harris to do some work for the U.S.G.S. gathering statistics on ground water in central and southern Louisiana.[11] Harris must have sent a proposal, perhaps asking for a rather high payment for his services, for there is a response from Newell a few weeks later offering only $600:

> ". . . for expenses and compensation during completion of field work and the preparation of the report on underground waters of Louisiana. . . . I should be very glad to have you undertake the work, notwithstanding the fact that the rate of remuneration you ask is higher than is ordinarily accorded a geologist under similar conditions. . . . There is no objection to the preparation of the report during free intervals while engaged in other work, providing it is ready to be submitted before January 1, 1904"[12]

Then Harris must have asked for more expense money in order to obtain better data, but Newell wrote him:

> "I appreciate the necessity of further field work in Louisiana for the purpose of determining the amount of the

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[8] To W. C. Stubbs, Director, Louisiana Sugar Experiment Station, Audubon Park, New Orleans, from C. M. Hicks, Treasurer, Sicily Island Oil Company, Wisner, Louisiana, December 31, 1902. HA-PRI, Ithaca, NY.

[9] To Prof. W. C. Stubbs, Audubon Park, City [New Orleans] from H. E. Gumbel, L. Gumbel & Company Ltd, Cotton & Sugar factors and Commission Merchants, New Orleans, December 31, 1902. HA-PRI, Ithaca, NY.

[10] Actually according to Harris, Veatch was working for both the U.S.G.S. and the Louisiana Geological Survey (Harris *et al.*, 1905, p. 1).

[11] F. H. Newell, U. S. Geological Survey, to G. D. Harris, Audubon Park, Louisiana, January 24, 1903. HA-PRI, Ithaca, NY.

[12] F. H. Newell to G. D. Harris, February 9, 1903. HA-PRI, Ithaca, NY.

> supplies derived from the wells. I would suggest, however, that approximate amounts are of nearly as great value as exact determinations, and can be obtained in a much shorter time and at less expense. The details of carrying on the field work and the preparation of the report are left to your judgment, but the sum of $600.00, which I mentioned in my letter of February 9th., is all that I feel at liberty to assign for the work in Louisiana, and, if possible, I should like to have you make the field and office expenses, including salary, come within this amount. Please let me know definitely at your earliest convenience whether or not you can undertake the work on the allotment mentioned, in order that we may arrange for its payment from this year's appropriation."[13]

Is this what is meant by the old saying, "Close enough for government work?" He must have accepted the $600, however, for Harris said in the introduction to the groundwater report:

> ". . . the writer spent the month of June 20 to July 20, 1903, in the same field in behalf of the U. S. Geological Survey." (Harris *et al.*, 1905, p. 1).

While this negotiation concerning the groundwater work was being conducted, Harris sent his own proposal to the U.S.G.S.:

> "Your application of December 24 [1902] for means to continue a systematic paleontologic and stratigraphic investigation of the eastern Cenezoic [*sic*] has been carefully considered by Messrs. Stanton, Willis, Dall and Vaughan. There is entire unanimity regarding the value of the work which you propose and its desirability at the present time. There is also a unanimous opinion that the work should be done under Survey auspices and that the results, both collections and notes, should belong to the Survey."[14]

No money was forthcoming, but at least the scientific merit of his proposal was accepted.

He also arranged cooperative agreements with other governmental agencies, such as the Coast and Geodetic Survey. In the Harris Archives is a copy of a letter to one Mr. Edwin Smith, Assistant, United States Coast and Geodetic Survey (USC&GS), from Superintendent [unnamed], December 23, 1902 which directs Smith to go to Louisiana and work with Harris in setting up a meridian line. This was part of a joint agreement with the USC&GS and Harris to do magnetic survey work in Louisiana. "Articles of agreement" from the Superintendent were sent for Harris to sign in letter on December 23, 1902. Through this joint effort, Louisiana became only the third state in the Union to, ". . . have a satisfactory survey made including all three elements-*declination, dip,* and *intensity*." [Emphasis in the original.] (Harris, 1905b, p. 171).

This was not the first time Harris had seen the need for such magnetic surveys. While working in Arkansas, Branner asked him to determine what it would cost to establish meridian lines in every county seat, and Harris estimated about $3500 and a year's work. This was not the kind of commitment Branner could support, so nothing was done. Then, when Harris came to Louisiana in 1898, he found little magnetic survey or meridian work had been done, but with an annual appropriation of only $2000, once again it seemed an impossible task. But if he could not do the work one way, he would do it another:

> "Accordingly, an engineer's transit (Heller and Brightley's) was borrowed from the Engineering Department of the State University at Baton Rouge and observations were made and markers were left at every parish seat traversed in general geologic work. The only losses thus entailed to geologic work proper were one day after a night's observations, devoted to finding and setting permanent monuments or markers, and the transportation expense of a few extra instruments." (Harris, 1905b, p. 173).

Harris continued this type of survey work for three years, and when the task became totally overwhelming, he asked the United States Coast & Geodetic Survey for assistance.

Much of the effort of the work by Harris and his assistants dealt as much with determining correct elevations and doing topographic mapping as it did with rocks and fossils. The topographic data available to them were minimal and often base maps had to be prepared before the geology could be mapped. For example, the appendix to Part II of *Bulletin* Number 1 is simply a compilation of altitudes in North Louisiana (Veatch, 1905). Part of this mapping activity relied on having proper compass headings, which, in turn, required establishing magnetic variations and meridian lines. This was very much "non-rock work", but still vital to the overall success of the Survey activities.

The attention to establishing meridian lines and their importance to the general mapping of the region was a lesson well learned by his students. Several years later one of his student assistants, J. Pacheco, who by then was working with the Commisão Geographica e Geologica do Estado de São Paulo, related the following:

> "This survey is now doing something in the way of determining meridian lines, and I thought I could possibly do something in the way of studying the influence of the

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[13] F. H. Newell, Chief Engineer, U.S.G.S., to G. D. Harris, Sugar Experiment Station, Audubon Park. HA-PRI, Ithaca, NY.

[14] C.M. Hayes, Geologist in Charge of Geology, U.S.G.S. to G.D. Harris, January 28, 1903. HA-PRI, Ithaca, NY.

> various rock masses in deviating the magnetic needle. We have here to contend with great trap dikes and overflows, which on decomposition gives a deeply red soil highly rich in iron oxide. Of course the needles behave crazily in such areas, but I thought that perhaps we could find some method in such behavior."[15]

In 1905, Harris changed the titles of the Survey reports he was producing. Up until this time he had been continuing a line of reports started by Lerch, *e.g.*, the 1902 report was Part VI of the series. He also changed the heading; "Geology and Agriculture" became "Geological Survey of Louisiana" to better reflect the type of work he and his assistants were doing. In addition, each report became known as a *Bulletin*, Report of [year] and numbered consecutively. Perhaps the choice of a name for the series of publications was influenced by his academic experience, and his own *Bulletins of American Paleontology*. In light of subsequent history, the letter of transmission from Stubbs, Director of the State Experiment Stations (the state office which controlled the survey) for the first *Bulletin* has an interesting statement in it:

> "The bulletins which follow will deal with salt, lignite, oil, etc., but these products are of most trifling account when compared to the great underground water supplies of the State." (Harris *et al.*, 1905, p. vii).

Today, however, no one would refer to the oil industry in Louisiana as a "trifling account."

At times, however, Harris' ideas on the importance of the Survey and its activities did not quite coincide with what the State expected, at least in so far as Stubbs represented the State's view. In a letter indicating that Harris had $2500 available after paying various expenses and salaries, Stubbs outlined various suggestions as to how he felt the money should be used:

> "You next speak of the volumes to be published, one on Economic Geology, another on Stratigraphy and topography, and another on Paleontology. I consider the first and second of the utmost importance just now, not because in themselves they are really so valuable, but because they will do to furnish to the large number of immigrants and land agents that are now invading this State with such information, and the object of this appropriation in the State is more to develop the material resources than for scientific research, although the latter is not lost sight of in the appropriation."[16]

Stubbs must have had his way, for in 1905, the published reports concerned only groundwater, altitudes, tide, and magnetic data, with not a single mention of paleontology (Harris *et al.*, 1905, pts I and II; Harris, 1905b, c, 1907b; Veatch 1905, 1906a).

By 1905, Stubbs was no longer in charge of the Experiment Stations and the new Director, W. R. Dodson, was not familiar with Harris and his work. Dodson inquired:

> "I am not acquainted with all the correspondence regarding the contract with you, and would be obliged if you would give me a statement of the months you are to spend in the filed [*sic*], and those which you are to spend in working up your reports.
>
> "I would also be obliged for a short resume of the work you have done this winter, the reports you have in preparation, and the number of publications now being issued, approximately what they will cost, when they will be ready for distribution and so forth.
>
> "What arrangements have you had regarding the survey paying the traveling expenses between Louisiana and Ithaca. I note on the first statement that you have your railroad expenses. Do I understand from this that we are to pay your expenses to and from Louisiana each season. Had I known you were going to return at this time to Ithaca, I should have requested you to come by Baton Rouge. I wanted to have a day or so with you and learn all about your plans, the work done this winter and many other things. I have given most of my time to the work that has needed my attention the most and have not yet given your work the consideration I wanted to. I hope in due time to become fully informed as to the what [*sic*] I can best do to promote the best interest of the work."[17]

Only a few years after Dodson replaced Stubbs as head of the Experiment Stations, there were hints of financial problems that were affecting the Survey work and publications:

> "I [Dodson] approve of your anxiety to get the Louisiana work before geologists of the country, and especially before the national department as fully as possible. I have no special reason to believe that the appropriation for the work in Louisiana will be discontinued, but it is always a fight to get appropriations and there is so much politics in the legislature that things are not always put on their merits, and we must always count on the possibility of having the appropriations cut off."[18]

And it seems Harris was, once again, having problems getting items printed by a governmental agency. This time it was a matter of having to use a "state printer" instead of a private print shop:

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[15] J. Pacheco to Gilbert D. Harris, March 22, 1909. HA-PRI, Ithaca, NY.

[16] W.C. Stubbs, Director, Louisiana Sugar Experiment Station, to G.D. Harris, October 13, 1903. HA-PRI, Ithaca, NY.

[17] W. R. Dodson, Director, Agricultural Experiment Stations, Baton Rouge, Louisiana, to G. D. Harris, March 29, 1905. HA-PRI, Ithaca, NY.

[18] W. R. Dodson to G. D. Harris, January 21, 1908. HA-PRI, Ithaca, NY.

> "I [Dodson] have your letter of the 21st, and note your suggestion for having the bulletin printed in New Orleans. I hardly think we could do this. The printing of the experiment station, and of the State Board of Agriculture was awarded to the state printer by a committee from the State Board of Agriculture appointed for the purpose of awarding the contract for printing. . . .
>
> ". . . Possibly by printing 5,000 copies instead of 7,000, . . . it will be an easier proposition."[19]

The *Bulletin* of 1908, Number 8 (Harris *et al.*, 1909) was the last of the series Harris and his students produced, for there was a change in leadership at the state level and the general funding for the work ceased. Among the final numbers of the Survey *Bulletin* was Harris' large work on rock salt (Harris, 1908), and later he continued his work on salt with a paper in *Economic Geology* (Harris, 1909).

The published work on salt certainly struck a responsive chord with his friend Branner, who was then Vice President of Leland Stanford Junior University:

> "I have no hesitation in saying that I regard it [the *Economic Geology* paper] as one of the most valuable and far reaching contributions that has been made to geology in this country for many years.
>
> "Since 1885 I have looked high and low for such evidence as you have here brought forward; but it is one thing to have a theory, and it is quite another to have facts and a theory too."[20]
>
> "Your salt bulletin [No. 7, 1908] was duly received and I thank you very much for it. It is not only good on the salt of Louisiana, but the best there is now on the general subject."[21]

One rather interesting map (Plate XXIV) in this 1908 report shows the relationship between the salt domes and the oil and gas areas of Louisiana and southeastern Texas, an idea which he continued to develop (Harris, 1909, 1912a, 1912b, 1913, 1915). Also, in this 1908 report, Harris gave what appears to be the first good description of what he called the "Sabine Peninsula." In a later report (Harris, 1910), he called it the "Sabine Uplift." This is one of the major structural features of northwestern Louisiana and northeastern Texas, and it has played a major role in various geological theories such as Powers' (1920b) "Positive elements in petroleum geology".

Harris certainly exploited his idea about salt domes during his days as a consultant to oil companies in Louisiana. In a report he did for the Pardee Land Company in 1912, he said:

> ". . . there are breaks in the underlying deposits and through these artesian saline solutions have arisen, concentrating, crystallizing, & [*sic*] pushing back and upadjcent [*sic*] deposits. . .And in Coochie brake [*sic*] the elevations clearly of salt origin have . . ."[22]

His ideas about the domes resulted in successful exploration because, as Harris indicated in an article about salt domes, the Myles Mineral Company,

> ". . . has had the courage to try out the theory and has discovered by the means a new oil field [Pine Prairie]. The director writes, 'I consider this a most remarkable vindication of a theory originated by you, and we [Myles Mineral Company] attribute a large measure of our success thus far to your advice.'" (Harris, 1912a, p. 546).

No doubt such statements appearing in print did much to enhance Harris' reputation as a consultant.

Although Harris was not an active researcher in the origins of salt domes after about 1915, he did try to keep abreast of the work of others. Several years later Harris was apparently not altogether pleased with a description of his salt dome theory by Sidney Powers and inquired about it. Powers replied:

> "You asked me the reason for certain of my views on salt domes expressed in my American Journal [of] Science paper [Powers, 1920a]. The mechanics of salt dome growth are admittedly unknown to me. But when Rogers pointed out that enormous volumes of water would have to be gotten rid of according to your theory I tried to choose the path of least resistance, and accepted tentatively the European view. But I do not think the cap rock was raised or grew with the salt."[23]

Somewhat later, Harris replied:

> "Now, as to the most plausible theories as you have stated the *volcanic* and the *uplift* I have always been at a loss to know how salt chunks covered unusually qua-qua-versally [*sic*] with calcareous thimble-like caps could possibly originate volcanically. I have made most complete magnetic surveys around some, especially Weeks Id [*sic*] [Island] to see if the usual deflections produced by volcanic phenomena are present, but they are not. As to the usual uplift theory, there may be no extremely serious objections to it in a dome devoid of great masses of cavernous, crystalline capping among the inner belt of domes, but how about the coastal rep esentatives [*sic*], where some of the salt

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[19] W. R. Dodson to G. D. Harris, January 25, 1908. HA-PRI, Ithaca, NY.

[20] J. C. Branner to Gilbert D. Harris, March 1, 1909. HA-PRI, Ithaca, NY.

[21] John C. Branner to Gilbert D. Harris, April 12, 1909. HA-PRI, Ithaca, NY.

[22] Typed copy of *Report on the Oil and Gas Prospects of the Pardee Co.'s Lands near Pine Prairie, La.* by G. D. Harris, August 24, 1912; attached to a carbon copy of a letter from O. C. Hathaway to "The Pardee Company, August 27, 1912. HA-PRI, Ithaca, NY.

[23] Sidney Powers to Gilbert D. Harris, September 13, 1920. HA-PRI, Ithaca, NY.

> chunks have been penetrated, have these lost their mooring from deep lying Cretaceous or Permian beds, and have they on account of lightness in specific gravity been shakeu [*sic*] up top as popped kernels of popcorn rise to the top while the heavier unpopped kernels stay at the bottom of the popper? Or have they been squirted up in a semi-solid state from those great depths as our foreign brethern [*sic*] suppose stopping strangely enough just wrere [*sic*] the squirting is easy, not far beneath the surface? Again, with all this upward shaking or squirting movement is it not strange that porous, crystalline, cavernous calcareous matter without traces of organic remains can come fr m [*sic*] no known sedimentary rock directly yet be there on top of the salt nicely in place in spite of the cavorting of its salty mount?
>
> "Does not the fact that these secondary crystalline masses are associated with geosynclines as you say rather suggest artesin [*sic*] action than volcanic or ordinary uplifting?
>
> "However, there is lots to be learned about these domes yet. Let others if they will, find more and describe them as you have done and the [*sic*] we will trust future results. I [*sic*] a hundred years or so I hope some one [*sic*] will redetermine the precise bench-marks I established some ten years ago to determine if differential uplifting was going on there now."[24]

Two years before Harris' death and almost 50 years after he had done his work on salt domes, the American Association of Petroleum Geologists was producing a new volume on salt domes, and wanted to include an "appreciative biography" in recognition of his pioneering work with these features. Walter Hopper[25], a former student who had worked with Harris in Louisiana in 1908, contacted him about the volume:

> "I assure you that my work with you as a student and later in Louisiana is very clear in my mind.
>
> "I realize that I am not writing a memorial. This makes it necessary, or at least advisable that I be more careful in what I say. *You* may read my story." [Emphasis in the original.][26]

By 1909, Dodson was not very optimistic about financial the health of the Survey:

> "I regret very much that the work that has been done is not more fully appreciated by some of those who hold the purse strings. The chairman of the appropriation committee has no appreciation for scientific work of any kind, and it is not his fault that the appropriation for other scientific work was not cut off. . . .
>
> "I have not been able yet to get any money from the State Treasurer on our appropriation, but I feel confident that when the Board of Liquidation meets that they will make arrangements for filling the appropriation, and we will be able to pay our bills."[27]

But the funds were not forthcoming and Harris' Geological Survey of Louisiana came to a close.

At no time was Harris' organization really well funded. According to Pope (1988), the maximum appropriation seldom exceeded $2500 per year. In a letter[28] in 1905, Harris told H. S. Williams that Louisiana gave him $5000 to spend as he saw fit. That must have been a well funded year, or perhaps Harris inflated the facts to impress Williams. In the "Prefatory Remarks" of his very first report in 1899, Harris sang a different song and bemoaned the lack of adequate financial support at that time:

> "The prosecution of a well organized geological survey demands an expenditure of funds far in excess of those now at our command. This the reader is requested to constantly bear in mind." (Harris and Veatch, 1899, p. 7).

Yet, financial support notwithstanding, Harris and his assistants made quite a contribution. Seventy-nine years after the close of this phase of the state survey work, this is how the Harris years were remembered; note the quotation from the first Harris report:

> ". . . [Much] extremely valuable topographic and cartographic work was accomplished, . . .
>
> "The work of Harris was amazingly accurate especially under conditions of the times. His efforts, and those of his assistants, contributed not only significantly to the geological knowledge, but greatly to the development of the natural resources of the state. The attitude of these tireless and astute workers is best expressed in the letter of transmission of the 1899 report in which the Director of the Experiment Station, William C. Stubbs said of Harris and Veatch, 'These two gentlemen have persistently followed their work through freezes and sunshine, over intolerable roads, impelled by an enthusiasm known only to lovers of science.' Conversely, credit should be given for the support rendered by the Director of the Experiment Station. Harris in his letter of transmittal to Dr. Stubbs in the Report of 1905 stated, '. . . you have cheerfully, promptly, knowingly expedited all matters relating to our State Survey with no compensation whatever save the knowledge of seeing the right thing done at the right time'" (Pope, 1988, p. 190–191).

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[24] Unsigned carbon copy, Gilbert D. Harris to Sidney Powers, November 2, 1920. HA-PRI, Ithaca, NY.

[25] Walter E. Hopper (A.B. '08; M.A. '10) was consulting geologist in Tulsa, Oklahoma at the time of the correspondence.

[26] Walter E. Hopper to Gilbert D. Harris, July 1, 1950. HA-PRI, Ithaca, NY. However, for unknown reasons, the volume was never published. The A.P.P.G. library has no record of it.

[27] W. R. Dodson to Gilbert D. Harris, February 1, 1909. HA-PRI, Ithaca, NY.

[28] G. D. Harris to H. S. Williams, April 12, 1905. H. S. Williams Papers, 14/15/728, Geological Correspondence Box, RMC-KL, Cornell.

Pope (1988) gave no reason for the closing of the Survey in 1909; other than the unspoken and obvious one, that the legislature did not appropriate any more money. It was not until 1914 that the Survey was re-established as the Louisiana Soil and Geological Survey.

Thus closed one aspect of Harris' commercial work, which, in turn, led to the opening of a new challenge for him as a geological consultant to various oil companies.

CHAPTER 6. CONSULTANT

The commercial aspects of geology and the work of academic geologists as professional consultants are often overlooked by historians of the subject, and yet commercial interests have been a driving force in the development of most geological surveys, on both sides of the Atlantic (Tweedale, 1991). While Harris was certainly not the first academic geologist to seek work in the commercial sector, he was very much at the forefront of the development of the oil industry in Louisiana in the early years of the Twentieth Century, and as it was such an important part of his life, that activity deserves more than a passing mention. The fact that Harris did most of his consulting by mail and by telegram makes this aspect of his career even more interesting. As these various letters between Harris and his clients are read, wonderful images come to mind of drillers sitting on the edge of the drill rig down in some Louisiana swamp with the crew playing cards, all waiting for the mail to arrive with Harris' instructions.

Exactly when Harris made the transition into the field of geological consulting is not known with any certainty, but from existing letters, it appears that consulting opportunities began to present themselves while he was serving as Geologist in Charge for the State of Louisiana. Information on a small printed sheet, probably prepared and printed by Harris and entitled "Stratigraphic Geology and Paleontology at Cornell," lists the following: "1916–1920 Louisiana professional geological work."[1] But there is evidence that he was involved with consulting activities long before 1916. It is difficult, however, to tell if the work he was doing, much of it by mail, was part of his Survey duties, or whether he was involved in private ventures.

Certainly as the oil industry began expanding with great rapidity during the first decade of the Century, there was increased pressure to supply geological information and assistance, perhaps with requests for more detailed information and quicker access than the published material would provide. Here is an example of one of the many letters requesting assistance which were sent to William Stubbs, Director of the Experiment Stations, the parent agency for the Louisiana Survey:

> "We have some very fine oil indications near Shreveport and I trust you [William Stubbs] will send one of your government geologists up here. I can send a jar of stuff taken from the top of the water here if it will be of any service. . . ."[2]

In 1905, four years before the demise of the Louisiana Survey, Harris received this letter from J. Numa Jordy in New Orleans:

> "I have your letter of the 27th. You have evidently misunderstood what we want in this matter. We are forming a stock company here to develop that Quarry and we want to know its commercial value as a Marble, for Lime or for any other purpose to which it may be put. Now, you are evidently very familiar with this property, and if you will get up a handsome report and make it as strong as your conscience will permit without overrating it, we will give you $1000 in the stock of the Company.
>
> "Please do this at once, and ascertain, if you please the other information that we are anxious to put in our prospectus, i, e, [*sic*] as to whether some of this marble was sent by the State of Louisiana to form a part of the Washington Monument, in the meanwhile tho' [*sic*] send the report we want, as we are waiting on it. . . .
>
> "State in your report that you have made a visit to this property and know all about it. Sign it officially."[3]

There is no record as to whether the report was sent; probably not, given the tone of the letter, but it does illustrate the kind of situations that were available to him during these early days of the oil boom in Louisiana and Texas. Even Stubbs seemed to be impressed with the rising interest:

> "I enclose you quite a number of letters lately received [*sic*]. Some of them may be of use to you, while others

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[1] Undated printed page. Pen corrections on it suggest a date of about 1945; its purpose is unknown. HA-PRI, Ithaca, NY.

[2] Henry Shepherd to William Stubbs, January 3, 1903. HA-PRI, Ithaca, NY.

[3] J. Numa Jordy to G. D. Harris, October 31, 1905. HA-PRI, Ithaca, NY.

> may be worthless. I send them as a proof of the widespread interest manifested in the work now going on in Louisiana."[4]

Even before the Survey closed Harris was corresponding with an I. N. Knapp, who appears to have been an independent operator, originally in Louisiana, and later in Philadelphia. There are a series of letters from Knapp to Harris starting in April of 1907 and continuing through 1910. No company name is given on the letterhead, just his name, I. N. Knapp. In some letters, Knapp described the fossils he was able to save from the well cuttings and said that he had them all labeled, waiting for Harris to stop by and see them. From this it seems that Harris was making visits to well sites:

> "My [Knapp] office man at Morgan City is Mr. J. F. Allen and you can Phone [*sic*] or wire him regarding going down to the well and he will have a boat ready for you on arrival of the train. The porter from the Gostellos Hotel meets all trains ask him [about the boat]."[5]

Samples were sent to Harris in bottles, small boxes, and even folded in the letters themselves:

> "Please find enclosed some fossils for determination. I would be glad to know their geological horizon."[6]

Harris and Knapp had more in common than just their mutual interest in the oil business:

> "I have two sons now at Cornell, Arthur Knapp, M.E. '07, Instructor in steam engineering [and] Walter Knapp student in the E. E. course. I was about 1 1/2 years at Cornell with class of '75."[7]

By 1915, Knapp's son, Arthur, worked on one of the first rotary drill rigs used in Russia.[8]

When the Survey ceased operations in 1909, Harris would have needed additional income to replace what he had been receiving as Geologist-in-Charge. Also, it was at this time that Harris ceased operations with the large geologic field camp held in the Helderbergs, and reverted back to less elaborate summer excursions with very few students. It is difficult to know whether a connection exists between the two events, but the timing certainly suggests one. By having the smaller summer activities, Harris would have had more time to devote to consulting.

The following letter is typical of the correspondence which was reaching Harris from Louisiana. Although not addressed to him, it was probably forwarded by Dodson, who had succeeded Stubbs as Director of the Experiment Stations:

> "With a view of trying, by boring, excavating etc., in the earth to ascertain whether in our part of the country there's minerals and deposits to justify the presence and aid of 'A 1' geologist, we thought it would be advisable to confer with you-relative to such an undertaking-feeling that you have the interest in and the development for such at heart. . . . Others have succeeded in such undertakings, and who knows what might happen in old Union Parish?"[9]

And as he explored the world of consulting, Harris did not overlook his own home state: "I have tried to obtain the information you asked me for about gas wells about Buffalo . . ."[10]; there followed a three-page (albeit small ones) description of various wells and their bearing strata.

By June of 1909, it appears that Harris was well and truly in the oil consulting business in Louisiana, for this date marked the beginning of a large volume of letters from "The Myles Mineral Company, F. F. Myles[11], President; MINERAL LANDS SCIENTIFICALLY EXPERTED, BOUGHT, LEASED AND DEVELOPED." At the left side of the Myles letterhead is a drawing of a wooden oil drilling tower with black liquid gushing out the top. The first of the letters from The Myles Mineral Company begin in 1909, but from the tone of the nine letters written between June and December that still exist from that year, it appears Harris had been working for the company prior to June, 1909, for the first letter reads as though it was part of an ongoing correspondence. There are 22 surviving letters from 1910; and similar numbers through 1915 at which point the record stops. Many letters had drilling reports enclosed with them informing Harris what depth had been reached and a description of the material found at the various depths. A large part of the surviving record consists of nothing but the drilling reports with no accompanying letter.[12]

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[4] W. C. Stubbs to G. D. Harris, January 12, 1903. HA-PRI, Ithaca, NY.

[5] I. N. Knapp to G. D. Harris, August 22, 1907. HA-PRI, Ithaca, NY.

[6] I.N. Knapp to G. D. Harris, September 27, 1907. HA-PRI, Ithaca, NY.

[7] I. N. Knapp to G. D. Harris, September 27, 1907, p. 7. HA-PRI, Ithaca, NY.

[8] Vivien L. Knapp (Mrs. Arthur Knapp) to Gilbert D. Harris, December 12, 1915. HA-PRI, Ithaca, NY.

[9] J. M. Anderson to J. G. Lee, February 3, 1909. HA-PRI, Ithaca, NY.

[10] Catharine M. Allen to G. D. Harris, June 22, 1909. HA-PRI, Ithaca, NY.

[11] Frederick F. Miles was a figure in the business world of New Orleans for many years and before venturing into the oil business, he began the salt industry in Louisiana with his mines on Weeks Island. He was a General in the Louisiana State Militia and was appointed as Quartermaster-General of the militia by the governor. He died in New Orleans July 1, 1915 at age 64. *The Times-Picayune*, page 4, July 2, 1915. The Historic New Orleans Collection, 533 Royal Street, New Orleans, LA.

Although Harris' replies by mail and telegram with his recommendations are unknown, from reading the Myles side of the correspondence, it seems that he was actually advising the company almost on a daily or at least weekly basis. When he was not teaching, Harris would travel South for actual field examination and to meet with his employers. This was possible after the demise of the Louisiana Survey because Harris continued on a half-time appointment at Cornell, with his teaching duties confined to rather reduced summer field activities and the fall term:

> "We are ready for the fourth attempt, and want you to locate the well; so, upon receipt of this if you are in position to do so, please wire me here when we may expect you."[13]

> "When you have examined these shells, please advise me here by *return of mail*, what you think of them; and if you think them good indication *please wire me here collect*, as we are getting a little discouraged with this hole." [Emphasis in the original.][14]

The Myles Mineral Company Secretary, H. M. Journee, appears to have been an interesting person. From his letters he seems to have been quite well educated, if not formally; and he certainly had given considerable thought as to how and where oil might be found, especially where the structural domes were concerned:

> "Since last hearing from you, I have been pondering a good deal on your intimation that you now think it possible that we have a considerable uplift in our section,—possibly extending several miles to the Northward, I take it.
>
> "Now, this has always been my idea, in a vague sort of way, and we were influenced by it in taking leases to the northward. As you will remember, we have no leases to the southward, except immediately adjoining us.
>
> "We are therefore extremely anxious to get your views after an examination of the shells sent you; for, should you feel confident of an uplift of considerable proportions, we would take several thousand acres more of leases."[15]

Earlier he had asked Harris for geologic literature on the eastern oil and gas fields, as reading them could, ". . . serve the purpose of my enlightenment."[16]

Harris must have had some success with his recommendations, for Journee wrote:

> "I note your [Harris] progress as a promoter and beg to offer my humble congratulations. There are some rocks, and shells, and such as that in the path of a geologist; but the real rocky roads, and the real shell games, lie in the path of the promoter."[17]

From his letters it appears that Journee had some geologic knowledge, or at least he had mastered some of the terminology:

> "Your letter of the 20th inst. has been forwarded here [Pine Prairie, Louisiana], and has been read with great interest.—particularly as I had been hoping that these shells would show us to be in the Cretaceous."[18]

And another time:

> "At the same time I am enclosing a perfect shell; so small as to be apparently insignificant, but in which you may find some interest. It was found in the cuttings from the 2050 ft. level; and I thought it might possibly be '*Fusus harrisi*.' "[19]

Given that Harris was actually on site only a few weeks each year, he had to use local people, such as Journee, to do his field work:

> "I too am much interested in knowing the relative location, as touching the dome formation, of the Anse La Boutte and Vinton wells; and it is my intention very shortly to go over to both places and make a careful examination, when it will afford me much pleasure to give you such information as my capacity may justify."[20]

Journee certainly had a sense of humor, which might have been a useful trait in his business:

> "Herewith I enclose as of possible interest, two specimens of what I took to be petrified wood. Can it be that we have come to the 'Stone Age.' Must have been rocky times, those."[21]

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[12] As I was taking these letters out of the envelopes during the summer of 1994, I often found small gravel samples folded inside the letter and a stream of particles would fall out as the page was unfolded.

[13] H. M. Journee, Secretary, The Myles Mineral Company to G. D. Harris, December 10, 1909. HA-PRI, Ithaca, NY.

[14] H. M. Journee to G. D. Harris, February 15, 1910. HA-PRI, Ithaca, NY.

[15] H. M. Journee to G. D. Harris, March 10, 1910. HA-PRI, Ithaca, NY.

[16] H. M. Journee to G. D. Harris, July 30, 1909. HA-PRI, Ithaca, NY.

[17] H. M. Journee to G. D. Harris, January 18, 1910 HA-PRI, Ithaca, NY.

[18] H. M. Journee to G. D. Harris, February 25, 1910 HA-PRI, Ithaca, NY.

[19] H. M. Journee to G. D. Harris, June 12, 1910 HA-PRI, Ithaca, NY.

[20] H. M. Journee to G. D. Harris, October 12, 1910 HA-PRI, Ithaca, NY.

[21] H. M. Journee to G. D. Harris, May 12, 1910 HA-PRI, Ithaca, NY.

Harris' ideas on the relationship between salt domes and the presence of oil proved worthwhile, but on occasion he apparently did not respond quickly enough to Journee's letters:

> "I have just returned from Vinton, and what I saw there 'looked mighty good to me.' All of the producing wells of any size are right alongside [*sic*] the salt dome,—one could stand on the dome and throw a biscuit (one of the kind we had at Eunice) across the best part of the field. While prospecting is going on very widely, the proven field is describing a crescent, and will, I believe eventually encircle the dome. Few, if any, people there, has [*sic*] any idea of the dome theory; and there may still be obtained on the South of the dome land that looks just as good to me at this time as the proven field. I would take some of it myself, were it not for the fact that I am convinced that we have a field of our own, and just as good. . . .
>
> "Any further information you may desire, I will gladly furnish; but it appears to me I am writing a good deal lately, and getting mighty few replies."[22]

Harris, it would seem, was not only being paid as a consultant, but was also offered an opportunity to invest in the wells:

> "Herewith I am handing you samples from about 110 feet, in the present well, #7. Please let me know whether or not they look good to you, as we intend to bring a gusher in here soon, and want you committed in advance."[23]

While Harris' idea about salt domes and oil seemed to be a good one, according to this letter, his advice was not 100% correct all the time. Journee was ready, however, with a fair geological reason to explain the anomaly:

> "Herewith I am handing you a clipping, showing that a well [at Pine Prairie] has been brought in at Vinton, after passing through 1,000 feet of rock. This would seem to upset your theory that little oil is to be found beneath [that] much rock, but, if my idea as to the location of this well is correct, it is right at the edge of the salt mass, and the oil has evidently penetrated a cavity in the rock from the side."[24]

Apparently Harris' lack of communication in 1910 can be traced to the building of his house at 126 Kelvin Place:

> "Am glad to learn that the new home will soon be completed, and I trust that, when once you have a place to live, you will be like most other people who build houses, prepared to travel about; and that you will be with us more than of recent days."[25]

But all was not going well at the well, so to speak:

> "The well is down to 1269 feet, in standstone [*sic*], saturated with oil, and showing much gas, and much 'smell.' If we don't get it this time, then you are discredited as a prophet. In other words, by one fell swoop, we will lose our phophet [*sic*] and our profits too. However, let us hope that this double disaster will not befall us."[26]

The well was a disaster, but for other reasons:

> "I have no good news for you. It looks that we are to lose the present well. At 1687 feet, and while drilling, a lot of rock fell in, jammed the drill stem, and they [the drill stem] pulled in two in trying to get out. We are still working on the hole, but have little hope to save it. . . .
>
> "We now want you advoce [*sic*], as to whether to drill alongside this hole, or try another part of the field."[27]

The Myles Mineral Company had better luck with well # 2, and they struck oil at 306 feet.[28] It is interesting to note that almost all of the letters from Journee begin, "Dear Doctor", and Harris apparently did not correct him as to his proper academic title.

The Myles Company had other successes:

> "I know you will be gratified to learn that we brought in a gusher on yesterday. Just what it will finally yield we cannot determine exactly, as we did not let it run to its full capacity, and now have it capped. However it flowed pure oil in a solid 4 inch stream, more than 60 feet high, and was constantly increasing when we shut it off.
>
> "I consider this a most remarkable vindication of a theory originated by you, and we attribute a large measure of our success thus far to your advice."[29]

Apparently Harris had a letter in the mail which crossed Journee's in which he was saying they would have to drill deeper:

> "Your letter of the 6th is received, and for once I find you a bad prophet, as we have already brought in a big well at a much less depth than you predict.
>
> "We are now arranging for tankage, and in about two weeks we expect to start it flowing. As you are the father of this field, it would be most appropriate that you should

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[22] H. M. Journee to G. D. Harris, February 8, 1911. HA-PRI, Ithaca, NY.

[23] H. M. Journee to G. D. Harris, March 13, 1911. HA-PRI, Ithaca, NY.

[24] H. M. Journee to G. D. Harris, April 6, 1911. HA-PRI, Ithaca, NY.

[25] H. M. Journee to G. D. Harris, April 14, 1911. HA-PRI, Ithaca, NY.

[26] H. M. Journee to G. D. Harris, April 29, 1911. HA-PRI, Ithaca,NY.

[27] H. M. Journee to G. D. Harris, July 10, 1911. HA-PRI, Ithaca, NY.

[28] Hand-written PS on letter from H. M. Journee to G. D. Harris, November 28, 1911. HA-PRI, Ithaca, NY.

[29] H. M. Journee to G. D. Harris, February 5, 1912. HA-PRI, Ithaca, NY.

> be present at the christening. Can't you get down about that time?"[30]

Harris seems also to have had a head for business as well as for siting of the wells:

> "Your idea as to sell outstanding leases is quite in accord with our own, except for the fact that I believe there is a series of domes in this section. . . .
>
> "While we don't wish to become too ambitious on account of slight success. The demonstration of your theory has been so complete in this instance, that we are minded to take up the prospecting of Belle Isle should we meet with large success in the present instance, I am in position to obtain a lease on the entire island, and as you are so thoroughly familiar with the matter, I would be glad to have your views regarding the possibilities of oil to be found there. As I recollect it, you were very enthusiastic about the island when last I saw you."[31]

Of course there is nothing like a little prosperity to bring on civilization, and the well was producing oil at a good rate:

> "Since I wrote you last, things have been moving at Pine Prairie,—we have a lot of new neighbors, plenty of new saloons, a dance hall or two, and several holes being drilled, but as yet no wells. . . .
>
> "After bailing the water out, it came back oil, and is running better than 1,000 bbls. [a day?], which we are shipping directly, as we do not intend to close it again."[32]

In an earlier letter, Journee said that oil from the Caddo Field was selling for $.60/ barrel.[33] Then assuming the yield figure quoted is barrels/day, that one well would create a gross income of about $600.00 per day. To help put this figure in perspective, Harris' salary at Cornell University, if he had worked full-time, would have been about $3,000 per year, or $250/ month. Thus, the gross income from that one well in one day was equal to more than twice Harris' monthly salary.

Journee continued to express his support for Harris and the relationship between the presence of oil and the salt domes:

> "All indications bear our [*sic*] your views that the oil will lie immediately adjoining the salt, and the test will now be to locate the contour of the salt dome."[34]

While Journee and Harris were corresponding about the wells owned by The Myles Mineral Company, Harris was receiving letters from W. D. Cheny[35] in Shreveport, Louisiana, and consulting with him on a project at the same time. Cheny enclosed land maps and well logs on wells drilled by the Cudahy Oil Company:[36]

> "I am enclosing you a map and a log of the well drilled by the Cudahy Oil Co. on the lease I made them, and I have lately acquired the well and the surrender of the lease. . . .
>
> ". . . I am sending you under separate cover some samples of the rock, shells and sand, . . ."[37]

In 1913, there was yet another company joining Harris' "stable", The Pardee Company. This group was headquartered in Philadelphia, and this connection apparently developed as a result of his work with The Myles Mineral Company in the Pine Prairie area. Harris did some preliminary work for The Pardee Company in late 1912[38], and there must have been an exchange of information between the two organizations as Journee knew Harris had some connection with The Pardee Company:

> "Am in receipt of a letter from The Pardee Company, stating that they have abandoned the idea of drilling at Pine Prairie, but they make no explanation whatever. In view of the many courtesies which I have extended these people, and the personal trouble and inconvenience I have been put to in their behalf, the letter is not at all what I should have expected. Can you give me, confidentially, any information as to the sudden change of front of Mr. Pardee?"[39]

Harris must have known nothing about the Pine Prairie project, or chose not to say anything:

> "Yours of the 12th is received, and I note that the Pardee people have not taken you into their confidence as to the cause of their delay. I was very much surprised at their sudden change of attitude and the brusque manner in which they announced it to me. However it is evident they have some plans which they desire to conceal, and as my interest

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[30] H. M. Journee to G. D. Harris, February 10, 1912. HA-PRI, Ithaca, NY.

[31] H. M. Journee to G. D. Harris, February 21, 1912. HA-PRI, Ithaca, NY.

[32] H. M. Journee to G. D. Harris, April 12, 1912. HA-PRI, Ithaca, NY.

[33] H. M. Journee to G. D. Harris, March 23, 1912. HA-PRI, Ithaca, NY.

[34] H. M. Journee to G. D. Harris, April 29, 1912. HA-PRI, Ithaca, NY.

[35] No information is known about W. D. Cheny, but apparently he was no relation to Monroe G. Cheney (Cornell B.S. '16).

[36] W. D. Cheny to G. D. Harris, November 29, 1911, April 20, 1912, and one undated letter missing page 1, but the information in it appears to be about the same well as the April letter and written near the April, 1912 date. HA-PRI, Ithaca, NY.

[37] W. D. Cheny to G. D. Harris, April 29, 1912. HA-PRI, Ithaca, NY.

[38] Copy of a report prepared by Harris for The Pardee Company, August 12, 1912. HA-PRI, Ithaca, NY.

[39] H. M. Journee to Gilbert D. Harris, February 8, 1913. HA-PRI, Ithaca, NY.

> is largely friendly and my efforts entirely gratis, I shall not trouble them further."[40]

But apparently Pardee was still in communication with Journee:

> "Just received a telegram, requesting that I meet Mr. Pardee in New Orleans tomorrow, and will advise you as to the outcome. Verily the Yankee commercial mind, like Providence, 'moves in a mysterious way its wonders to perform' "[41]

Journee apparently was looking after Harris' interest as a consultant, as well as his own interests; note the use of the word "us":

> "Today I had a conversation with Mr. Wexler, Vice-President of the Largest [*sic*] bank here, and he states that he wants us to go to Honduras this Summer [*sic*], and he requested that I write and ask whether or not you can go. Your compensation would be $500.00 per month and expenses, and the trip would be a most interesting one. Please let me hear from you, and if you can arrange to go, I will make definite arrangements."[42]

But Honduras was too much even for Harris to undertake at that time:

> ". . . I note your plans for work during the coming year; and upon further consideration I quite agree with you that it would be well to devote whatever time you can spare this summer to Louisiana work, and defer the Honduras trip until next winter. I will immediately take this matter up with Mr. Wexler and ascertain whether or not this will meet with his views."[43]

Harris replied to Journee agreeing with the postponement, but he certainly wanted to keep the project alive, if possible:

> "I think it is quite proper to let the Honduras proposition rest over until next winter if it will keep. In fact I am writing this particularly to let you know that this so far as I am concerned will be possible for next winter, because I have already made arrangements with the Trustees to allow me the same leave of absence the coming winter as I had during the past, namely from about December 22nd to February 6th. This will give us ample opportunity for investigating any equatorial proposition."[44]

The monthly salary quoted by Journee apparently was Harris' standard rate and, no doubt, one of the reasons why Harris was drawn to this work.

There was no further explanation from Journee as to why Mr. Pardee wanted to meet with him, but Pardee may have wanted to ask him about Harris' work as a geologist, for by May, 1913, The Pardee Company was back in touch with Harris:

> "I am advised by my son Ario Pardee that you are willing to continue to serve my Company, or myself, or both, as heretofore, looking over the lands of The Pardee Company, to advise where to search for Gas, Oil, or Salt, and, in addition, to advise as to additional purchases of lands where in your opinion these minerals or elements may be found, and on the terms hitherto paid you,—Five Hundred Dollars per month and your expenses. In addition, we are to pay for the necessary surveyors, etc., to aid you, and also their expenses.
>
> "You are to spend two months on this work the coming summer and one month next winter.
>
> "In addition to your salary and expenses, we are to give you a five percent interest in the lands purchased in the territory where you think a new stratum oil field, similar to the Caddo field, may be found."[45]

As this offer came when his maximum annual salary at Cornell was only $250 per month, needless to say, Harris accepted almost immediately:

> "Herewith I am returning some clippings from the Shreveport Times sent to me by your Mr. Hodge. . . .
>
> "As regards your personal letter of May 2nd, the conditions you mention are entirely satisfactory to me, and I shall take great pleasure in working out the stratigraphy of the east portion of the Sabine uplift. I really believe herein is the secret of future development that is worthy of serious consideration"[46]

Pardee was quite happy that Harris had accepted the terms:

> "I need not say I am pleased that the conditions named in my letter to you of May 2nd are entirely satisfactory to you and that you will be prepared to go to Louisiana sometime in July."[47]

At this point it is necessary to note that now Harris was working for The Pardee Company (Philadelphia), Mr. C. Pardee, President, and for The Myles Mineral Company (New Orleans), Mr. H. M. Journee, Secretary, both at the same time. Also, the officials of each companies appear to have known of his affiliation with the other company, for Harris was open with Journee that he was now working for another company:

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[40] H. M. Journee to Gilbert D. Harris, February 25, 1913. HA-PRI, Ithaca, NY.

[41] H. M. Journee to Gilbert D. Harris, March 12, 1913. HA-PRI, Ithaca, NY.

[42] H. M. Journee to Gilbert D. Harris, March 17, 1913. HA-PRI, Ithaca, NY.

[43] H. M. Journee to Gilbert D. Harris, March 28, 1913. HA-PRI, Ithaca, NY.

[44] Unsigned carbon copy, Gilbert D. Harris to H. M. Journee, April 7, 1913. HA-PRI, Ithaca, NY.

[45] C. Pardee, President, Pardee Land Company, to G. D. Harris, May 2, 1913. HA-PRI, Ithaca, NY.

[46] Unsigned carbon copy, Gilbert D. Harris to C. Pardee, May 7, 1913. HA-PRI, Ithaca, NY.

[47] C. Pardee to Gilbert D. Harris, May 12, 1913. HA-PRI, Ithaca, NY.

> "I shall be down in Louisiana further to the north however, for the Pardee people next summer, and doubtless shall be through by Pine Prairie sometime before the University opens in the fall."[48]

Apparently Harris' reputation was spreading; the following is another example of many such letters from this time period requesting his services, this one from the "Bank of Boyce, Boyce, Louisiana":

> "We understand you have been doing some geoligist [*sic*] work for the Pine Prairie Oil Co, also for S, [*sic*] Gumble of New Orleans. We want some work of this kind in Rapides Parish, near Boyce. Are you in a position to do any thing [*sic*] of this kind at the presant [*sic*] time, and if so, what are your usual terms, and what machinery would be necessary for the initial work, if any."[49]

And another, this time with a letterhead, "Fox-Renaud Grocer Company, Limited; Pure Food Grocers" in Monroe, Louisiana, also requesting Harris' help:

> "Associates and self have in contemplation drilling for oil or gas in this parish. Could we secure your services or some other competent person to locate the place to drill, if in your opinion, indications are such as to justify sinking a well and what would you charge for the services." [*sic*][50]

This time Harris declined, but he did offer some free advice:

> "Replying to your favor of the 15th, I must say that from my experience in the state of Louisiana, I could not recommend the expenditure of money drilling for oil in northeast central Louisiana, or in the parishes immediately around Monroe. . . . Again, since I shall be occupied most busily all summer in oil investigation in other parts of the state where I have more confidence in the locations, I could not find time to spend with you as suggested in your letter."[51]

It was at this time that the Hodge character, mentioned in a previous letter, made a major entrance into Harris' consulting activities. This episode also demonstrates that the latter part of the Twentieth Century does not have a monopoly on unscrupulous behavior. Based on a letter from Pardee to Harris May 17, 1913, there was some trouble brewing. Pardee wrote:

> "Mr. Hathaway writes me under date of 5/22/13:
> 'There has been some parties from your territory that is [*sic*] trying to buy some land in the immediate sections where we have been trying to buy, and I am unable to ascertain how these people got this information, unless the same came from your office. However, I learned yesterday that Mr. Thos. [*sic*] L. Hodge had been in Shreveport and also in New Orleans while I was in Tennessee. This might account for the interference.'
>
> "I have written Mr. Hathaway to know exactly *where* efforts had thus been made to secure lands in the territory where you have already made, or propose making, examinations and reports in my interest.
>
> "I dismissed Mr. Hodge April 30, 1913, since which time he made a visit to Louisiana, reported by Mr. Hathaway.
>
> "I have thought it best to advise you of Mr. Hodge's dismissal and of his reported efforts to buy lands in Louisiana in what I might term my territory and in which you are to have an interest, as I fear he has been trying to get lands in what you think may prove a possible second Caddo field[52]." [Emphasis in the original.][53]

A few months prior to this, in March, Hodge had returned a page from Harris' report which described those lands.

Harris shared his thoughts on the situation with Journee:

> "I am informed from Mr. Pardee of Philadelphia that Mr. Hodge is no longer with the Pardee Company and the intimation is given me that Mr. Hodge has been in Louisiana apparently taking advantage of the geological knowledge gained through association with me while in the Pardee employ. All of this I hope is in some way due to some slight misunderstanding, for I do not wish to consider Mr. Hodge a traitor, but I thought it my duty to give you this pointer, which you may be on your guard as to what statements Mr. Hodge may make to you if he is that character of a person seemingly indicated by what little I have received from the Pardee people of late. The only suspicion I have felt regarding Mr. Hodge was (1) as I have already written you, I see no necessity whatever of his taking time and expense to go to Louisiana to help write my report for I had promised to stop in Philadelphia and tell the Pardee people all I knew; (2) I became slightly suspicious on account of the over religiousness shown ostentatiously, or without cause in many instances by Mr. Hodge. I always

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[48] Unsigned carbon copy, Gilbert D. Harris to H. M. Journee, May 8, 1913. HA-PRI, Ithaca, NY.

[49] William Jonlaw to G. D. Harris, January 4, 1913. HA-PRI, Ithaca, NY.

[50] Charles Schultz to Gilbert D. Harris, May 10, 1913. HA-PRI, Ithaca, NY.

[51] Unsigned carbon copy, Gilbert D. Harris to Charles Schulz, May 19, 1913. HA-PRI, Ithaca, NY.

[52] The Caddo oil field was first developed about 1904 (Harris *et al.*, 1909). Production peaked in 1913, and by January 1, 1920, the Caddo Field had produced over 81 million barrels of oil. On March 10, 1920 it was still producing over 17,000 barrels per day (Powers, 1920b).

[53] C. Pardee to Gilbert D. Harris, May 27, 1913. HA-PRI, Ithaca, NY.

> feel very suspicious of a person who takes particular pains to state that he is very, very religious, and especially if he has serious fears of my immortal soul. After what has happened and the very crooked morality displayed, if such it really turns out to be, I feel almost inclined to write to Mr. Hodge and ask how about his own immortal soul."[54]

Apparently, Hathaway (in New Orleans), Harris (in Ithaca), and Pardee (in Philadelphia) did not move quickly enough, for only a few days later, Harris wrote to Pardee:

> "I think Mr. Hodge has made a serious mistake in any way you may consider it, for first, it seems to me [Harris] that upon his [Hodge] representation of what seems to be a good thing to any company in Shreveport, the question will immediately be raised as to what authority he bases his judgement upon, and if he declines to tell they will immediately suspect something is wrong, and in case he should tell said companies will more than apt to write to me some inquiries regarding the matter, and I cannot help thinking aside from the moral aspect of the matter, he has made a most grievous mistake. What could have lead [*sic*] him to such miserable actions, I for one cannot imagine."[55]

Harris then received the following:

> "Your letter of 2nd inst. has been received and I will write Mr. Hathaway to-day [*sic*] to better describe the 4040 acres referred to in his letter May 28th and the 1000 acres referred to in his letter to me of 5/22/13, copies of which I enclose you [*sic*].
>
> "Mr. Hathaway wired me yesterday from New Orleans that the scamp Hodge and friends had closed for the 4000 acres (which I believe to be the 4040 acres)."[56]

To further complicate this situation, there seems to have been some financial connection between the two companies, at least on some of the drilling prospects. Here is part of a letter from Journee, Secretary of The Myles Mineral Company:

> "The Pardee well is now down more than 2500 feet, and when I left yesterday, was in water sand with many shells, so it looks like a dead one to me, and I told Hincy he could have our interest if he wanted to go deeper."[57]

About two months before Hodge was dismissed by Pardee, Harris had received a short letter from none other than Thomas L. Hodge who was returning a page from one of Harris' reports. From the closing in the letter, it would appear that Hodge and Harris had more than a passing acquaintance:

> "Enclosed is sheet [page] no. 19 of your Report which must belong to your copy, as our copy and that sent to Hathaway are complete . . .
>
> Mrs. Hodge wanted to be remembered when I wrote again."[58]

Another interesting note is that the page Hodge was returning just happened to be one that has part of the description of "A New Stratum Oil Field" and mentioned:

> "Such facts as we now have tend to cause us to believe that in the extreme south of Bossier and southwest extreme of Webster Parish a monoclinal structure exists that, in case oil has been generated in this district of Louisiana, should produce a duplicate of the Caddo field. . . . Again, we have determined that on Lake Bistineau nearly along the Webster-Bienville line it is not the Claiborne Eocene that appears at the surface but the Sabine, just as in the Caddo field! [Emphasis in the original.][59]

It was in June that Harris must have written to Journee about Hodge, for he received this reply:

> "Yes; we have Mr. Hodge in our midst, so to speak. He has been down here twice within the last thirty days, and is at present in Shreveport. He came to me about two weeks ago and stated that he wanted to buy some cheap lands in the Lake Bistineau section, and I turned him over to Mr. Giddens of Campti, with the understanding that he (Giddens) and I divide any profit that might be made; and I understand from him that he has sold Hodge the 4,000 acres immediately adjoining the lake on the west, in Township 16, Range 10. I don't know just what Mr. Hodge has in view, but my impression is that some of his friends have put up this money and are carrying him for an interest in the purchase. If Hodge is stealing Pardee thunder, and Hathaway says that he is, I don't know just exactly how he satisfies his conscience; but he tells me that he attended Sunday school in Shreveport, and urges that I do so on the occasion of my next visit there. He also expressed much concern for my spiritual and moral welfare, and I know he thinks that poor Babcock is utterly damned."[60]

The saga continued, with Harris very much involved. From Pardee, Harris received a letter dated June 12th and with it was a copy of a letter to Pardee from Hodge. First is Hodge's letter to Pardee and then Pardee's accompanying letter to Harris:

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[54] Unsigned carbon copy, Gilbert D. Harris to H. M. Journee, May 30, 1913. HA-PRI, Ithaca, NY.

[55] Unsigned carbon copy, Gilbert D. Harris to C. Pardee, June 2, 1913. HA-PRI, Ithaca, NY.

[56] C. Pardee to Gilbert D. Harris, June 5, 1913. HA-PRI, Ithaca, NY.

[57] H. M. Journee to Gilbert D. Harris, January 27, 1914. HA-PRI, Ithaca, NY.

[58] Thomas L. Hodge to Gilbert D. Harris, March 3, 1913. HA-PRI, Ithaca, NY.

[59] Part of an unpublished report, page 19, attached to a letter from Thomas L. Hodge to Gilbert D. Harris, March 3, 1913. HA-PRI, Ithaca, NY.

[60] H. M. Journee to Gilbert D. Harris, June 5, 1913. HA-PRI, Ithaca, NY.

> "At Pine Prairie yesterday I [Hodge] learned from Mr. Journee, for the first time, that you had been offered a portion of the 4000 acres at Lake Bistineau recently purchased for my friends. I think you should know the circumstances under which I acted.
>
> "When you [Pardee] dismissed me from your employ, it was, of course, necessary for me to secure other employment, and I came to New Orleans to see Mr. Journee about another matter. He told me of a report which Dr. Harris made to his friends last year of a possible new oil field, and said that if I could raise any money he thought he could get me some cheap land in that neighborhood, naming a price at which he agreed to buy it. I accepted the proposition with the understanding that nothing should be done to embarrass Mr. Hathaway in any negotiations he might have in hand. I returned to Philadelphia, completed my arrangements for the purchase of a thousand acres, and on receipt of telegram from Mr. Journee, went to Shreveport, where he told me that there were 4000 acres in the tract, which my people agreed to take. It was not until the week after I had agreed to take the property for my friends and arranged for the money, that I learned of Mr. Hathaway being after it. I was then committed to my friends. . . .
>
> "I felt entirely free to secure the land in that territory after Mr. Journee had volunteered the information regarding Mr. Harris' report of last year, showing that the information was not the exclusive property of the Pardee Company; also from the fact that you said in the office some time ago that you could not, of course, buy all the land in that neighborhood, and further, that you said to Mr. Ario [Pardee, son of C. Pardee], in my hearing, that you had already secured 3000 acres on the lake. . . .
>
> "If I have interfered with your plans, it was unintentionally done, and I very much regret it, having supposed, as stated above, that you had already secured a large holding in that neighborhood"[61]

Pardee's assessment of Hodge's explanation, as he explained to Harris, was not very high:

> "I am to meet him [Hathaway], and will ascertain what he knows of Mr. Journee's reports to Mr. Hodge as to Hodge's explanation in second paragraph of his letter, of your report of last year to Mr. Journee's friends of a possible new oil field based on which Hodge claims he bought the four thousand acres.
>
> "I can only say Hodge was fully aware of your report made this year in my interest and even marked on one of our office maps of Louisiana the exact location of the territory where you thought might be found a second Caddo Oil Field and I naturally assumed he was using confidential information gained while in my employ to my detriment. Hodge's explanation is one that does not explain in my opinion. In view of your statements that the information you gave of this supposed oil field was to be confidential he should not have gone into this territory except with your consent and mine."[62]

But now the plot thickened. Again from Pardee:

> "I returned from Bristol, Va., yesterday after an interview with Mr. Hathaway, who says your Report, which Hodge mentions in his letter of explanation, was the one you made Julius Weis & Sons and its contents were made known by Mr. Journee to both Mr. Hathaway and to Mr. Hodge in Mr. Journee's office.
>
> "Mr. Hathaway also states that Hodge had a copy made of your report to The Pardee Company which he [Hodge] virtually stole from me and gave it to a Mr. Giddens of Shreveport while buying through him the 4040 acres on the west side of Lake Bisteneau [*sic*].
>
> "I also learned through Mr. Hathaway that The Gulf Refining Company have recently renewed their oil leases in the Lake Bisteneau [*sic*] section and that very little land remains without leases."[63]

Pardee enclosed for Harris a copy of his letter to Hodge, and from the last section it seems Harris shared his letter from Journee with Pardee, or Pardee had communicated with Journee himself. Pardee wrote to Hodge:

> "Your [Hodge] letter of June 9, 1913, has been received, but your explanation does not explain, as you deliberately appropriated while in my employ and took from my office a confidential report made by Dr. Harris for and at the expense of The Pardee Company, of which I am practically the owner, used it for your advantage, and furnished a copy to a Mr. Giddens[64] (and who I believe still has it) through whom you bought about four thousand acres of land in the territory recommended by Dr. Harris.
>
> "As you are noted for your ostentatious concern for the welfare of the souls of others, let me suggest that the welfare of your own soul needs especial looking after in view of this breach of trust by you."[65]

So now it appears that Harris was involved with yet another company, Julius Weis & Son, at the same time as the other two major companies. But none of this seemed to change Harris' relationship with either major company as shown with the following letters; first from Pardee, in what appears to be the finalé to the Hodge story, and then from Journee:

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[61] Typed copy of a letter, Thomas L. Hodge to C. Pardee, June 9, 1913. HA-PRI, Ithaca, NY.

[62] C. Pardee to Gilbert D. Harris, June 12, 1913. HA-PRI, Ithaca, NY.

[63] C. Pardee to Gilbert D. Harris, June 18, 1913. HA-PRI, Ithaca, NY.

[64] T. K. Giddens of Campti, Louisiana. From the surviving letters it appears that Harris was advising him on geological matters as well as advising him on where to send his son to study geology, Cornell or Louisiana State University; Unsigned carbon copies, Gilbert D. Harris to T. K. Giddens, October 2, 1913; November 17, 1913. HA-PRI, Ithaca, NY.

[65] Typed copy of a letter from C. Pardee to Thomas Hodge, June 18, 1913. HA-PRI, Ithaca, NY.

> "I [Pardee] still think it advisable that you [Harris] should go to Louisiana, as we have plenty of work for you there for the summer, and I shall expect you to do so and wish you would report to Mr. Hathaway, to whom I shall send a copy of this letter.
>
> "Hodge has replied to my letter of the 18th instant [*sic*], copy of which I sent you, as follows:—'I [Hodge] acknowledge that I did wrong in giving to another information from your office, and I ask your pardon for so doing.' I don't think Hodge shall ever get my pardon, and my only regret in the matter is that he cannot be punished as he deserves for his breach of trust."[66]

Then from Journee

> "Should Pardee decide to curtail his investigation this Summer [*sic*] I [Journee] can readily arrange for you to put in your time to advantage, as our mutual friend, Mr. Learned, of Natchez, is very anxious for you to make a comprehensive investigation of the section to which we paid a visit last Summer [*sic*]; and in any event I expect to arrange with Mr. Pardee for you to put in at least a couple of weeks at Natchez."[67]

Harris' response to Pardee must have been a positive one, for Pardee replied:

> "Your telegram has been received and I enclose you a check for Three Hundred dollars, and I infer you will be likely be prepared to start for Louisiana soon after July twentieth, . . . [to do] the examinations I would like you to make, which will, of course, include the Lake Bisteneau [*sic*] territory, even though Hodge so shamefully and outrageously took away about four thousand acres of it. . . ."[68]

But the Hodge affair would not go away, and it had made Harris very cautious, for almost four months later, he wrote to Pardee:

> "I am enclosing herewith a letter recently received from New Orleans, the import of which you will quickly grasp. . . .
>
> "Were you here, I would be glad to discuss this letter more in detail, but knowing how matters discussed before Hodge regarding my own opinion touching matters in Louisiana, and finding the same disclosed and commented upon freely by people in New Orleans, I think it best to say little at the present time, although I do not believe you will suffer again in the immediate future from men like Hodge."[69]

Then another reference to Mr. Hodge was made in one of Journee's letters, and it appears that Journee used the word "friend" in a sarcastic manner:

> "About a week ago your friend Mr. Hodge called on me here and stated that you would be astonished if you knew how closely he had followed your work during the past Summer [*sic*]. He also showed me a number of fossil shells in rock, taken from some point where you had made an examination, but he declined to state where. He asked me to ascertain what the shells were, but I told him I was not interested.
>
> "Whether intentionally or not, there is no doubt that Hodge has circulated so many reports throughout the entire section as to make it very difficult for Pardee to obtain cheap lands; and if you have found anything which you think it advisable to buy, I would suggest by all means that the negotiations be left to a third party, and that party be unknown in the transaction until such time as the purchases be completed. There is no doubt in my mind whatever that the Castor property could have been bought much cheaper in this manner. The nature of country people is such that I make practically all of my purchases through local men, even when buying only for land and timber values, and in sections generally recognized to be barren of minerals."[70]

The relationships with The Myles Mineral Company and The Pardee Company appear to be typical of the manner in which Harris went about his consulting, albeit all the more colorful due to the "scamp" Mr. Hodge; namely by mail and telegram, with the occasional site visit. As Harris maintained a connection with some companies for ten years, the results gained from following his advice must have been successful. A few of Harris' letters with instructions and advice have survived and these provide a brief look at the consulting services the companies were getting for their money. This one was written to Journee:

> "It certainly is little unlooked-for [*sic*] to have the flanking clays extend to the depth of 1200 feet; yet of course we must expect that there will be projections and inflections making the dome quite irregular about the periphery.
>
> "This seem to be the first well you have sunk in one of the inflections or bays in the dome and it naturally suggests for the well either no oil at all or a far greater and more satisfactory supply at a greater depth.

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[66] C. Pardee to Gilbert D. Harris, June 26, 1913. HA-PRI, Ithaca, NY.

[67] H. M. Journee to Gilbert D. Harris, June 27, 1913. HA-PRI, Ithaca, NY.

[68] C. Pardee to Gilbert D. Harris, June 30, 1913. HA-PRI, Ithaca, NY.

[69] Unsigned carbon copy, Gilbert D. Harris to C. Pardee, October 6, 1913. HA-PRI, Ithaca, NY.

[70] H. M. Journee to Gilbert D. Harris, October 1, 1913. HA-PRI, Ithaca, NY.

> "Hoping the latter condition will prove to be the correct one, . . ."[71]

The second one, to Pardee, is more detailed, and with definite conclusions, but they are presented in an almost "stream-of-consciousness" writing style that is difficult to follow:

> "I have also indicated on the map that in the central portion of the domw [*sic*] you may expect to find a large mass of salt. This will doubtless be flanked by porous limestone and gypsum. Similar to that we were in in Well No. 1. At Winfield just outside will be upturned sedimentary deposits and in the porous layers of such deposits in this particular case cretaceous [*sic*] formations such oil and gas accumulations as may have been formed in this region will naturally be found. A well located not too far a way [*sic*] from the salt center would naturally penetrate these cretaceous [*sic*] beds in an undisturbed condition, hence they would doubtless contain no special concentration of hydro carbons [*sic*]. Hence the location of Well No. 2 at Castor as you find it on your map still farther away from the sands of the dome outside of your main purchases you would doubtless find between one and two thousand ft. of tertiary [*sic*] sands containing a considerable amount of water to at least a thousand feet or more in depth. This then is the general scheme of this dome and a well or two of no great depth about the northern portion should indicate its oil potential."[72]

The advice given by a consultant can be only as good as the information received and at times Harris did suffer from insufficient information:

> "I have received your communication regarding the log of the well you were engaged in sinking, but I must confess that one can get only the most meager conception of what is really being done by a mere statement as a driller sees it in the field. What we want is actual specimens, particularly of the life that is generally in the form of sea shells that are brought up, that we may see whether or not low-lying formations have been bent up near the surface there and hence give us reason to suppose that such structures exist as may lead to the accumulation of Hydro Carbons [*sic*]."[73]

The Myles Mineral Company appeared to have dropped out of Harris' consulting stable by about 1915; at least that is when the surviving letters cease, about two years before the death of F. F. Myles. Letters and drilling reports from the Pardee company continued at least until 1923[74].

With the amount of consulting available to him and with companies willing to pay him four times his monthly, half-time salary from Cornell, it is easy to understand why Harris was very anxious to have this half-time arrangement continued, and even made permanent. He wrote to J. G. Schurman, Cornell University President:

> "A year or two ago you were kind enough to make an arrangement with me in my work whereby I substituted certain weels [*sic*] in the field in the summer for a few weeks between Christmas recess and the beginning of the second semester. . . . Now I am extremely anxious that this scheme, which has certainly worked with the greatest benefit and success to the students and University in general, should be continued and I am asking you therefore if you will kindly refer to the minutes of the action above referred to and see whether such action were [*sic*] taken to mean as a permanent arrangement or for last year only, . . ."[75]

It is interesting to note that Harris was apparently under contract to several companies at the same time, and was, no doubt, charging each of them his full monthly rate, but none of this was mentioned in his letter to the Cornell President. Also, the consulting work seemed to be taking Harris away from other academic projects, for he wrote to a Professor Lyford at Middlebury College:

> "As regards a text book on Paleontology for second year students, I can sympathize with you, because I have felt the need of exactly what you call for. In fact, I have already started such a text book to be published by Ginn & Company, but owing to lack of time the publication will be delayed for some years yet."[76]

By early 1915, apparently H. M. Journee was no longer employed by The Myles Mineral Company, for he was writing to Harris on a variety of company stationary, *e.g.* "Lake End Store", "Polk-Fenner Company Real Estate", and "The Lampton Realty Company"; still sending Harris drilling information and requesting assistance and professional advice. By 1920, Journee was with "Invincible Oil Company", Fort Worth, Texas. From the letters, it is difficult to determine just who was paying Harris for his information, the company or Journee himself, who then passed the material on to the company.

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[71] Gilbert D. Harris to H. M. Journee, February 17, 1914. HA-PRI, Ithaca, NY

[72] Gilbert D. Harris to C. Pardee, October 12, 1914. HA-PRI, Ithaca, NY.

[73] Unsigned carbon copy; Gilbert D. Harris to C. Pardee, December 15, 1913. HA-PRI, Ithaca, NY.

[74] Well log from "Henderson Syndicate's Pardee No. 1", December 1, 1922 to March 2, 1923. HA-PRI, Ithaca, NY.

[75] Gilbert D. Harris to J. G. Schurman, October 16, 1914. HA-PRI, Ithaca, NY.

[76] Carbon copy of a letter (unsigned), Gilbert D. Harris to C. A. Lyford, March 17, 1913. HA-PRI, Ithaca, NY. No record of such a manuscript has been found in the Harris Archives.

Over the next four or five years Harris continued to work for a variety of companies and individuals examining material from Brazil to the West Indies to Louisiana and Texas. A partial list includes: "Freeport Sulphur Company", Freeport, Texas; "Crystal Ice and Bottling Company, Ltd.", Natchitoches, Louisiana; "Mer Rouge Oil and Gas Company", Morehouse Parish, Louisiana; "Ouachita Natural Gas & Oil Company", Ouachita, Louisiana; "Progressive Oil & Gas Company", Morehouse Parish, Louisiana; "Chestine Land Corporation"; "Louisiana Oil Refining Corporation", Shreveport; "Sinclair Exploration Company", "The Texas Company"; "Trinidad Petroleum Development Company"; and "Standard Oil Company."

Harris had used students as assistants when he was directing the Louisiana State Survey and, at least by 1914, his students were involved in the consulting business as well, following in the footsteps of their professor:

> "Work here is just over for me this term. I am out every week end [*sic*], acting as consulting and field geologist for one of the big oil companies of the state."[77]

And another student, who was to later accompany Harris on one of the *Ecphora* trips, Karl Schmidt, wrote:

> "As there has been no pause in the drilling here I have not gone to Winnfield this week, and hence not talked with Hincy. I may as well send in what meager information I have from Mr. Hines, and report later on conversation with Mr. Hincy."[78]

From Schmidt's letters, it appears that he was working for Harris as a field representative in Louisiana while he was doing other collecting work. In the letters, Schmidt made several references to collecting snakes, insects, etc.

Although there is no record that Harris ever made the Honduras trip mentioned previously, even before 1920, his students were being employed in foreign ventures[79] and companies were contacting Harris about potential employment and requesting recommendations:

> "I have been authorized by Mr. D. F. McDonald, Geologist for the Sinclair Central America Oil Corporation, to employ a number of geologists for work in the Republic of Panama. The men are wanted for a period of six months beginning the latter part of December and of course all expenses including traveling will be included. I would be glad to hear of any men who you care to recommend. You, no doubt, can understand that men with German names have considerable difficulty in traveling nowadays but this need not be a serious drawback if they are American born."[80]

Those who went to foreign lands always seemed to keep in touch with Harris, for there are many rather lengthy letters from former students. Axel Olsson was a frequent correspondent; from Panama he wrote:

> "A few weeks ago I returned from a ten week trip to the Pearl Islands and to the interior of Panama. Before that I had been pretty much on the move with only a few days in town at a time.
>
> ". . . The fossil collections have been shipped to the Smithsonian but as soon as the war is over I hope to get busy on them. . . . and of greatest interest a large nautiloid, probably the *Enelimatoceras alrichi* Vaughan on the bases of the very small and incomplete fossil collection made by MacDonald has correlated this Eocene with the Wilcox, but don't you think it is more apt to be your Midway?
>
> "I have spent quite a bit of time in the Darien that part of Panama which borders Colunbia [*sic*]. Geographically it is the most interesting part of the republic [*sic*], contains the largest river, is inhabited by black Panamains [*sic*] and by friendly and hostile Indian tribes. With our launch *Bertha*, we ascended the Rio Tuyre to Real and Yarisa. Both are old towns which were founded by the Spaniards some 400 years ago . . . For this river work, use is made of a long, slender, dug-out canoe with flattened bow and stern. . . . One man stands at the bow and another at the stern and by poling progress is made against the current and up over rapids. These boatman are wonders at the work . . . In this way one can go far up the small shallow rivers and over bad looking rapids. Coming down is at first quite exciting but the novelty gradually wears off. A river may take 3 or 4 days to ascend may take only half a day or less to descend, especially as often happens during a flood. . . . In the Tuyre valley the Cunas are friendly but in the upper [illegible] are hostile against strangers of any kind. Their country is closed and very little is known regarding it. . . .
>
> "In the Tuyre valley we have a geologic section some 10,000 feet thick of which 3000 feet are highly fossiliferous. . . . This will make an interesting subject of study by itself.
>
> "Yesterday I helped take our launch *Bertha* through the Panama Canal. It seemed like our old days on the Barge Canal and the good old Delaware and Chesapeake. Some day we must have another *Ecphora* trip."[81]

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[77] Irving Perrine (A.B.'07, M.A'11, Ph.D.'12) to Gilbert D. Harris, January 29, 1914. At this time Perrine was on the faculty of The University of Oklahoma. HA-PRI, Ithaca, NY.

[78] Karl P. Schmidt to Gilbert D. Harris, February 13, 1915. HA-PRI, Ithaca, NY. This letter from Schmidt in Louisiana was written on Cornell University, Department of Entomology letterhead.

[79] A. C. Veatch was writing from England in 1914. A. C. Veatch to Gilbert D. Harris, November 7, 1914. HA-PRI, Ithaca, NY.

[80] D. Dale Condit to Gilbert D. Harris, November 10, 1917. HA-PRI, Ithaca, NY.

[81] Axel Olsson to Gilbert D. Harris, October 6, 1918. HA-PRI, Ithaca, NY.

Through the influence of A. C. Veatch, his former student and assistant during the Louisiana Survey days who was then with Sinclair Oil Company, Harris was hired by the Trinidad Petroleum Development Company, Ltd. in 1919. In a memorandum Veatch described Harris this way:

> "2. In a region where the geology is of the character of that in Trinidad, it is quite important to have Paleontological assistance. I [Veatch] wrote [R. H.] Soper to send the fossils to Professor G. D. Harris of Cornell University, the greatest authority in the world on American Tertiary fossils, saying that I was writing Professor Harris asking what arrangements could be made with him, or through him, for examining the fossils which Soper would send him from time to time, and for reporting to Soper on their stratigraphical significance.
>
> "3. At the same time I wrote Professor Harris asking if he could accept the position of Consulting Paleontologist to the Company and asking also if an honorarium of $1,000 per annum[82] would meet the case,—the Company to pay, in addition, all freight and transportation expenses.
>
> "4. I now have a letter from Professor Harris accepting this basis."[83]

In the contract Harris received from the Trinidad Petroleum Development Company, in addition to indicating the salary would be $1,000 per year, were two interesting clauses; very interesting, indeed, in light of difficulties that developed about seven years later with Maury. The clauses were:

> "3. The specimens sent you will be your personal property, except for such sets of representative examples of characteristic forms as may be of value for a reference collection for the field geologists working for the Company in this area.
>
> "4. The Company has no objection to your publishing descriptions of new fossils found, but you will not be free to make publication concerning general stratigraphical results at any time within five years from the date of the receipt of the collections without approval of the geologist in charge of the Trinidad work, which approval will be on the basis that such publication will not prejudicially affect the commercial interests of the Company."[84]

This last clause is quite interesting, also, in light of the philosophy Harris apparently imparted to his students:

> "Now if there is anything that I can do for you in the way of visiting localities, collecting fossils, taking photographs, or any other information either regarding Trinidad or the mainland of Venezuela across the Gulf, remember you have but to ask. There are, as I have often heard you say, scientific things which are above ones [*sic*] duty to any company and if while I am there I can get you any information which may help you in your work or possibly save you a trip down I will only be too glad to do so. I have not forgotten the innumerable things you did for me when I was at the university."[85]

Within six months of Harris taking the position with the Trinidad Petroleum Development Company, Soper left the Company and Gerald. A. Waring[86] became Harris' contact in Trinidad, and the two men were to continue their working and personal relationship for many years. Harris did not, however, make a very auspicious start with the Company:

> "We received a short letter from you dated September, 1st. [1919] in which you said that you were working on our material, but we have heard nothing from you since then. I also wrote you on 22nd. September, and sent a few fossils by mail, from two wells, but have not received an acknowledgment to date. We are particularly anxious to hear from you in regard these latter fossils—whether or not they are of any value. You understand, of course, that if the material we send you, is to be of actual value in this particular survey, the data [*sic*] will have to be available by the end of August, 1920 at the latest, since the final report and maps will probably be prepared during September and October, 1920."[87]

So in 1920, Harris went to Trinidad, his first trip overseas since his visits to England and France in 1894, just after he had accepted the position at Cornell (Palmer, 1953c). But this time he was going for consulting purposes and was being paid. In a letter to Waring in May, 1920, Harris mentioned his plans:

> ". . . am planning so that if the Pearsons will help me on my field expenses I can take next year off for field work at least for the early months of 1921."[88]

Later, Waring confirms his 1920 trip:

> "Since you sailed for New York, Mr. Kip has put in a

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[82] This pay rate was still in effect in 1923, for Harris received a check for $500 which covered the, ". . .half yearly payment. . ." N. F. Hill to Gilbert D. Harris, January 3, 1923. HA-PRI, Ithaca, NY.

[83] *MEMORANDUM to The Board of the Trinidad Petroleum Development Co. Ltd. Regarding a Paleontologist for the Trinidad Work.* Initialed "ACV" in Veatch's handwriting, July 14, 1919. Trinidad Box, HA-PRI, Ithaca, NY.

[84] Contact between Trinidad Petroleum Development Company Ltd. and Gilbert D. Harris, July 17, 1919. Trinidad Box, HA-PRI, Ithaca, NY.

[85] R. A. Liddle to Gilbert D. Harris, January 2, 1921. HA-PRI, Ithaca, NY.

[86] G. A. Waring came to the Trinidad Petroleum Development Company, Ltd. after working for the U.S.G.S, and later he worked for Margay Oil Corporation (Tulsa, Oklahoma). Harris named *Venezuela waringi* in his honor.

[87] R. H. Soper to Gilbert D. Harris, December 18, 1919. Trinidad Box, HA-PRI, Ithaca, NY.

[88] Carbon copy, Gilbert D. Harris to G. A. Waring, May 2, 1920. Trinidad Box, HA-PRI, Ithaca, NY.

> couple of days on the lower part of the Brasso section; . . ."[89]

Although not mentioned by Palmer (1953c), a letter from Waring in 1921 suggests that Harris made a return trip to Trinidad the following year, from which he was late returning to Ithaca and missed the beginning of the fall term:

> "I was pleased to receive your letter of the 20th. October and to learn that you had reached home safely with all of your material. . . .
>
> "We are interested to learn of Cornell's new President[90], and I presume it was in connection with his installation that some dissatisfaction was felt with your late return to the University. I fancy, however, that the incident has been wellnigh [*sic*] forgotten by this time, and doubtless the inconvenience to you was not such as to detract from the advantage of spending a few days longer here in in [*sic*] Trinidad."[91]

During the 1921 excursion, Harris collected material from over 100 localities[92], and he returned to Trinidad again in 1923[93] (Harris and Hodson 1922, 1931; Harris 1926; Waring 1926):

As a measure of the respect he enjoyed among the professionals working on Trinidad, it appears there is a mountain there named after him[94]. Also, during the 1921 trip, Harris managed to arrange a meeting to discuss stratigraphic nomenclature of Trinidad, attended by geologists from all the oil companies working there; Trinidad Petroleum Development Company, Ldt., United British W. I. Petroleum Syndicate, Ltd., Trinidad Leaseholds, Ltd., Trinidad Central Oilfields, Ltd., and Apex Oilfields, Ltd.:

> "This meeting was called partly at the instance of Prof. G. D. Harris of Cornell University, who wished to discuss the matter with geologists of the principal Oil [*sic*] companies, before he returned to the States. This meeting was also in part in response to a desire expressed by Drs. Ganz and Kugler[95] [respectively representing the United British W.I. Petroleum Syndicate, Ltd. and Apex Oilfields, Ltd], to exchange ideas with Professor Harris about a uniform system of nomenclature to be adopted by the leading geologists working in Trinidad. . . .
>
> "As a result of the meeting the following formation names were tentatively agreed upon, but without discussion of their geologic age, or even of their equivalence or sequences—

	Matura Formation
Moruga Formation	Caroni Formation
	Manzanilla Formation
Naparima Formation	Tamana Formation
San Fernando Formation (Palo Seco Facies)	Pointe-a-Pierre Formation
San Fernando Formation	
San Fernando Argiline Formation"[96]	

There seems to be a connection between Harris' work in Trinidad and his re-publication of the paleontological writings of Guppy (Harris, 1921), as both occurred at about the same time.

His 1923 visit to Trinidad was made while returning from a consulting trip to Venezuela.

> "After spending two months in Venezuela a stopped [*sic*] by in Trinidad for two weeks and Waring and I had a final look over the Island."[97]

By the early 1920s a former student, Ralph Liddle[98], was working in Venezuela for Standard Oil Company, and he seemed to be Harris' contact for the Venezuela portion of the 1923 trip:

> "I am glad to hear that you are well and that you intend going to Venezuela on an excursion with Mr. Lidall [*sic*] [R. A. Liddle]"[99]

Later Liddle forwarded some photographs to Harris showing him sitting on a "gallant steed on the La Velg anticline" taken during the Venezuela trip.[100]

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[89] G. A. Waring to Gilbert D. Harris, October 8, 1920. HA-PRI, Ithaca, NY.

[90] On June 30, 1921, it was announced that Livingston Farrand, former President of the University of Colorado and Chairman of the American Red Cross, would become President of Cornell University (Bishop, 1962).

[91] G. A. Waring to Gilbert D. Harris, November 10, 1921. Waring File, Trinidad Box, HA-PRI, Ithaca, NY.

[92] Locality list of all 109 sites is in the Trinidad Box, HA-PRI, Ithaca, NY.

[93] G. D. Harris field book with title "Trinidad" which starts on August 7, 1923 and the last entry is August 16. Trinidad Box, HA-PRI, Ithaca, NY. Attached to a letter from Waring is a list of collecting localities for Harris which has the dates "August-September, 1923" on it. G. A. Waring to Gilbert D. Harris, September 24, 1923. HA-PRI, Ithaca, NY.

[94] "River between Mt. Harris and Plum Mitan Rd." Quotation in a letter from H. G. Kugler to Gilbert D. Harris, November 13, 1924. Kugler File, Trinidad Box, HA-PRI, Ithaca, NY.

[95] Harris continued correspondence with Kugler for 30 years. H. G. Kugler to G. D. Harris: first letter, June 12, 1923; last letter, July 3, 1951. Kugler File, Trinidad Box, HA-PRI, Ithaca, NY.

[96] *Notes of a meeting held at the residence of G. A. Waring, in Port of Spain, on the 22nd, September, 1921, to discuss the adoption of an Uniform Series of names for the various Geologic formations of Trinidad*, p. 1 and 5. Trinidad Box, HA-PRI, Ithaca, NY. These names were used a year later in a stratigraphic column sent along with a letter to Harris by G. A. Waring, October 24, 1922. HA-PRI, Ithaca, NY.

[97] Gilbert D. Harris to H. G. Kugler, December 25, 1923. Kugler File, Trinidad Box, HA-PRI, Ithaca, NY.

[98] Ralph Alexander Liddle (Cornell A.B.'18).

[99] H. G. Kugler to G. D. Harris, December 6, 1923, p. 4. Kugler File, Trinidad Box, HA-PRI, Ithaca, NY.

Palmer (1953c) stated that the Venezuela trip was in 1924, but, although he made a second trip in 1924, Harris' letter quoted above clearly states that he was in Venezuela in 1923 working for the Standard Oil Company[101]. And a letter from that company, dated September 5, 1922, suggests that he was hired in late 1922, at the same time as Floyd Hodson, another of his students:

> "We desire this work to be under your general supervision so that Mr. Hodson and the Venezuelan organization can call on you at any time for advice. We shall in all probability count on your making a trip down there next summer [1923] to see that the work is being properly handled and to give personal attention to it.'
>
> "As to the matter of compensation, I am authorized to make you an offer at the rate of $700 per month for time actually devoted to the work, whether in the field or in the laboratory, with all official traveling and field expenses while in the field."[102]

The material he collected on these consulting excursions plus the material collected by his students and returned to his laboratory, created a very valuable resource. Harris described the situation this way:

> "I now have enough material from Santo Domingo, Jamaica, Costa Rica, Panama, Peru and Venezuela so that I can begin to work to advantage, in fact have the best outfit going on west Hemisphere Paleontology [*sic*] of the later formations, and more coming from Venezuela, Peru, Columbia [*sic*] and Argentina."[103]

As more data became available, modifications had to be made in previous stratigraphic positioning of some of the strata. A former student of Harris', Carlotta Maury, had proposed some of the earlier nomenclature and organization (Maury 1917a,b, 1918, 1925):

> ". . . thanks especially for the copy of Miss Maury's bulletin on the Miocene and Pliocene of Trinidad[104]. Will you kindly extend to her my sincere appreciation of the recognition she gave me, in naming several new forms. You mention that her stratigraphy does not quite accord with ours, and in checking hers (pp, 16–17), against my latest geologic column (of Oct. 1924), I find the following:
>
> | | Miss Maury | Waring |
> |---|---|---|
> | Freeport-Todd's Road | Upper Miocene | Lower Pliocene |
> | Springvale | Upper Miocene | Upper Miocene |
> | Brasso | Middle Miocene | Upper Middle Miocene |
> | Godineau River | Middle Miocene | Upper Middle Miocene |
> | Manzanilla | Lower Miocene | Upper Middle Miocene |
> | Machapoorie | Lower Miocene | Upper Middle Miocene |
> | Tamana | Lower Miocene | Upper Middle Miocene |
>
> "The discrepancies seem to be chiefly as to Godineau River, which we place equivalent to Machapoorie; and Manzanilla, which we place as Upper Middle instead of Lower Miocene. This can be taken care of, I suppose, in a footnote to our paper, in accordance with your latest determinations."[105]

These excursions into foreign countries were not without their hazards, especially medical, and after his 1924 trip to Venezuela, Harris suffered from an illness and it took him many months to recover:

> "I regret to state that I have been doing practically nothing this fall since I returned from Venezuela, having contracted amebic dysentery while there and having been confined to the house or hospital most of the time."[106]

This illness continued to trouble Harris and almost a year later he received this letter:

> "I am very sorry to hear of your illness, in which you have my sincere sympathy, for I had amoebic dysentery for thirteen months some years ago . . .
>
> "I am glad for the few remarks on Trinidad stratigraphy which you were able to give me in spite of your sickness, . . ."[107]

Not only was Harris venturing into foreign lands, but as indicated above, his students were doing the same thing, often in more exotic places and conditions than their professor. Olsson worked in Panama and Costa Rica, Liddle in Venezuela, and in 1921 Harris received a letter from Dean E. Lounsbery[108] (BS '19). Not only does this letter describe the hardships endured while doing geological fieldwork, but it illustrates the willingness with which Harris' students apparently undertook such tasks; a willingness they, no doubt, acquired through their association with Harris. Another interesting point about many of these letters which came back to Harris, aside from the geological discussion, is the political insight they show. Perhaps this is a measure of the broadness of the education they received from Cornell and from Harris. Lounsbery wrote from Ponnagyun, Burma:

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[100] R. A. Liddle to Gilbert D. Harris, October 15, 1923. HA-PRI, Ithaca, NY.

[101] Further support that he was in Venezuela in 1923 comes from this quotation: "After spending two months in Venezuela a [*sic*] stopped by in Trinidad for two weeks. . ." Gilbert D. Harris to H. G. Kugler, December 25, 1923 (original). Kugler File, Trinidad Box, HA-PRI, Ithaca, NY.

[102] C. F. Bowen to Gilbert D. Harris, September 5, 1922. HA-PRI, Ithaca, NY.

[103] Gilbert D. Harris to H. G. Kugler, December 25, 1923 (original). Kugler File, Trinidad Box, HA-PRI, Ithaca, NY.

[104] Probably Maury, 1925, which was published March 27, 1925.

[105] G. A. Waring to Gilbert D. Harris, April 27, 1925. Waring File, Trinidad Box, HA-PRI, Ithaca, NY.

[106] Gilbert D. Harris to H. G. Kugler, November 11, 1924. Kugler File, Trinidad Box, HA-PRI, Ithaca, NY.

[107] J. A. Bullbrook to Gilbert D. Harris, September 3, 1925. Waring File, Trinidad Box, HA-PRI, Ithaca, NY.

[108] Later Assistant to the Vice President for Land and Geological Department, Phillips Petroleum.

> "I haven't forgotten my promise to write, but in fulfilling that promise, I must admit a decided slowness on my part. I cannot imagine that almost a year has passed since I started globe trotting. In that year I have done considerable traveling especially in India, for a young blood; on the go almost continually since last January, but far be it from me to complain or kick for I am having the time of my life, and later on I will be sure to realize that is so, even more than now.
>
> "Last season from January to April I was with the party of D. D. Condit, formerlly [*sic*] of the U.S.G.S., which was conducting a rapid reconnaissance of the foothills adjoining the Kirthar Range in Sind and Baluchistan. There were two others in the party—Mr [*sic*] Nuttall, 23; and Mr [*sic*] Maynard, 24, from Chicago, a protege of Prof Salisbury's. We covered a large amount of territory, and most all by camels; the joys of riding via camel are to be compared with seasickness in the last degrees, and coupled with that there is always the unpleasant and nauseating odor emanating from the camel's nostrils. We always had siwars or mounted guards who sat in front of the hump to drive them, water being scarce and the siwar naturally dirty, you can figure the rest.
>
> "The country was rugged and barren of vegetation-a true desert. Water was very scarce at many places, and the natives said that there had been no rain in the last three years and only once in the last five. The geological end however was very interesting. Formations were very distinctive and one had little trouble in identifying horizons. The main Tertiary formation of the area is the Kirthar Nummulitic Limestone, and there was never any doubt about it, as whereever [*sic*] found it was always abundantly filled with Nummulites[109], of several distinct and easily identified types. During the season we found and mapped many beautiful anticlines and they were certainly excellent to look at from the standpoint of structure. We failed, however to locate any proof of petroliferous horizons underneath them. . . .
>
> "By the Middle [*sic*] of April the weather was so hot that further work in the field was very near impossilbe [*sic*], let alone foolish. . . . The Company maintained a summer headquarters at Dalhousie, a beautiful little hill station at the edge of the outer Himalayas. The elevation there is 7,000 feet, and consequently cool throughout the hot season. All of the staff with the exception of Dr. Wrights [*sic*] party came there to do office work, the latter being in Assam, the most convenient station was Shillong. The atmosphere there proved very pleasant to Mr. Weeks[110], and he was captivated by a very nice English girl, who last October became his wife.
>
> ". . . The moonsoon [*sic*] lasted until the middle of September, and then Dr. Knox, who is my present chief, and I started off into the Himalayas to do a little mountain climbing. . . . Various places along the route chosen afforded log rest houses. The highest pass which we went over was in the Central Himalayas at an elevation of 14,400 feet. On that particular day, unfortunately for us, there was a howling snowstorm [*sic*] in progress, which prevented taking any pictures of the first range of the Inner Himalayas. . . .
>
> "This season the Company sent us into the Arakan coast region of Burma. The country so far as geology is concerned is virgin soil. The Indian geological staff has examined and reported on only the costal [*sic*] and accessible regions. The Burma Oil Company geologists did some work in here, but so far as we can find out, they did not trouble themselves much where the jungle growth was thick. Our program calls for a complete examination of the entire strip, clear up to the Arakan Yomas. True enough the jungle is thick but one can always get through as there are many trails both animal and native. When I first heard of our assignment, I had visions of wild animals, snakes, leeches and jungle, as all were reported by the party in Assam. So far, I would not ask for a more ideal place to geologize in. We have not seen any tigers, wild elephants or bison; all terrors of the jungle, and as for snakes, they two [*sic*] are scarce. Malaria is very bad during the rainy season, but we will leave before that time. . . .
>
> "India is all astir now that the Prince of Wales is out here. The non-co-operatore are getting bolder every day and it will not be long before the government will have to step in and call a halt. Mr [*sic*] Ghandi's influence is very far reaching amongst the Hindus and the sooner things are brought to a showdown the better. Circumstances are getting graver in the Punjab every day as that has been the seat of all the trouble. I am not at all sorry that I am in Burma this year. The effect of Irelands [*sic*] being granted a Free State will have considerable influence here."[111]

Such consulting work, aside from the adventure, also paid the young people well. In 1922 after completing his work for the Sinclair Oil Company in Costa Rica[112]

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[109] A type of fossil foraminifera.

[110] Believed to be Lewis George Weeks, a graduate student at Cornell, 1919–1920, who later worked with Standard Oil Company (New Jersey).

[111] D. E. Lounsbery to Gilbert D. Harris, December 18, 1921. HA-PRI, Ithaca, NY.

[112] Not above a little politics as well as geology, A. C. Veatch, who was then working for Sinclair Oil company, suggested to Harris that Olsson dedicate the Costa Rican work to the National Museum or to the ". . . scientists of Costa Rica. This I think desirable from a company standpoint." A. C. Veatch to Gilbert D. Harris, January

(Olsson, 1922), Olsson wrote to Harris that he had been hired as a paleontologist for $5,000 per year by the International Petroleum Company[113], and by February of that year he planned to be in Peru.

In fact, for Olsson, the constant lure of consulting work kept him from completing his Ph.D. Each time he would return to Ithaca to begin the residence requirements and his thesis on the Miocene of Virginia, he would be hired for another overseas assignment. But that did not stop his interest in scientific work and Olsson published almost 4000 pages of material during his career, a total that does not include the countless pages of company reports that he wrote (Moore, 1978). Olsson's 1922 trip to Peru was the beginning of nearly 30 years of work in South America, work in which he was so successful[114] that the companies gave him freedom of movement and unrestricted permission to publish on the material he found[115]. Olsson and Harris formed an effective team, Harris with *Bulletins of American Paleontology*, the avenue for publication, and Olsson with a constant stream of new fossils from his oil company explorations. For Peru alone, Olsson's collections resulted in seven major works, 750 pages and 128 plates, on the paleontology of that country (Olsson,1928, 1929, 1930, 1931, 1932, 1934, and 1944), which Harris published.

Material returned to Harris by his former students working in foreign lands would also often provide the samples for others to study. For example Palmer (1923) used material sent from Costa Rica by Veatch and over 20 years later she used samples collected by Weisbord (Palmer, 1945).

As one reviews the many letters Harris received from his former students as they pursued industry and other tasks, one cannot help but be struck by what a difference their geological training made in their view of the world when compared to non-geologist. These young people saw a different world before them than the one seen by ordinary citizens. In reading one of Olsson's letters, written shortly after his arrival in Peru, one imagines how differently a non-geologist would have described the scene; one feels the excitement Olsson must have felt as he gazed at this Peruvian landscape for the first time. He described the landscape with these words.

> "Back a short distance from the sea, the country is generally high, a flat plain or tablayo covered with Pleistocene gravel. This plain near the coast and along the dry rivers is chiefly dissected by dry arroyas or gullies revealing the Tertiary rocks underneath. This dissection results in a badland sort of topography with most wonderful exposures so that the whole structure and relations of the beds is laid bare before ones eyes. It is a most ideal country for geology I have ever seen."[116]

Others with foreign assignments included the Hodsons, Floyd and Helen (Hodson, F., 1926; Hodson, H., 1926; Hodson, F. *et al.*, 1927; and Hodson and Hodson, 1931), and Norman E. Weisbord (1929, 1934). Weisbord, like others before him, took an interest in the local politics as well as the geology; at times he was in considerable danger himself. From Cuba in 1931, Weisbord sent Harris a description of the political and social conditions of the people and a hypothetical, but all to real, description of how certain government officials might operate. The conditions he described eventually led to several revolutions and much political instability on the island. Also, Weisbord's comments show how corruption in one country is often supported and exploited by others, even by people in our own country:

> "But enough of geology and on to politics. The revolution is definitely over tho [*sic*] there are occasional rumblings of another one brewing. Tho [*sic*] our press generally treats these political upheavals in a comic operatic vein they are serious affairs frequently resulting in loss of life, economic paralyzation and a bitter aftermath. I was in a sense in the thick of it inasmuch as I was working in the field all the while, tho [*sic*] my movements were constantly hampered by the rural guard who always had to examine my stuff and cross examine me. I protested in one place and got a good crack over the shoulder with the soldier's rifle and for a moment I thought the darned thing might go off. It is a sinking sensation to have a gun waved in front of you by an exceedingly mad soldier (who perhaps had had no sleep for several nights and very much on edge). I thought of lots of things during the interval. I was sent up to the guard house to the seargent [*sic*] for carrying khaki clothes (prohibited) a medicine chest and sundry instruments which looked like bombs I guess. The seargent [*sic*] . . . [had] . . . a kind, dumb face and I wheedled permission to go on

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23, 1922. HA-PRI, Ithaca, NY. Olsson did mention the "Officials of the National Museum of Costa Rica" and "Dr. A.C. Veatch" in the "Preliminary Remarks" to the paper (Olsson, 1922), although there is no record that Veatch ever actually graduated from any college (Heroy, 1942).

[113] A. A. Olsson to Gilbert D. Harris, January 22, 1922. HA-PRI, Ithaca, NY.

[114] One well in 1924 was the largest gas well ever drilled in Peru up to that time with 26,000,000 cu. ft. of gas. A. A. Olsson to Gilbert D. Harris, February 26, 1924. HA-PRI, Ithaca, NY.

[115] Sometimes there was a delay with that permission, "In a couple of years or so, there should be no reason why the stuff cannot be published, but at the present time the company is very close on giving out any kind of information." A. A. Olsson to Gilbert D. Harris, February 26, 1924. HA-PRI, Ithaca, NY.

[116] A. A. Olsson to Gilbert D. Harris, February 21, 1922. HA-PRI, Ithaca, NY.

> ahead. I showed him my passport which he scrutinized and said it looked alright [*sic*] but it *was* somewhat difficult to read. Since the incident I don't talk snotty to any soldiers.
>
> "Of the various Latin countries I have visited, this one seems to be the most corrupt politically, possibly because I've been more exposed to it here. The revolution was entirely warranted, tho [*sic*] it is quite possible that the new regime would have been as bad as the present and in all probability worse. There is no more thought of service to the people than there is common honesty in higher circles. Our own government is bad in spots, let's recognize it, but we do have some legislators and executives with a really earnest desire to do the right thing. This is usually very difficult in a democratic form of government hence our frequent failures. But here the prime reason of holding office is for the graft involved. The higher the circle the bigger the 'reward.' Compared to Venezuela which is avowedly the most autocratic of the South American states, this system is elephantine in its corruption compared to measly Venezuela which hasn't a penny [of debt] outstanding. This lovely little island of perhaps 4 million people is in debt to the tune of nearly a *half billion dollars*—with hardly anything to show for it. Here is the way its [*sic*] done, with the connivance of U. S. banks. I'm Joe President, let us say. I can't milk my people any more they're dry—have been since the 'gorda vaca' or dance of the millions during war time when sugar was selling for over 20 cents a pound. Well now, I and my clique have to have some money. We get our crooked heads together and we conceive of a great highway to span the entire island. We don't need such a highway for 50 years to come but it looks nice, it makes a show for tourists and above all it gives us a chance to get in on as easy a dollar as ever trickled thru [*sic*] the financial sieve. I, as president, controlling every phase of the government get Congress to pass a bill authorizing let us say 50 million dollars for highway 800 kilometers long, done up pretty good style. If congress doesn't O.K. this plan, why by hooky I'll take the lottery rights away (another prolific source of 100% graft). Congress benignly passes the bill without a whimper. That item taken care of, I have to get 50 million dollars. That's easy! We call in Mr. Bullblower of National City Bank and say we want 50 million dollars. Mr. B. says alright [*sic*] that can be arranged quite top hole. Cuba floats a public works loan of 50 million dollars, the National City Bank underwrites it giving public works let us say 40,000,000 dollars—that is they actually pay 90 dollars for a 100 dollar bond or some such figure. Public Works now has its 40,000,000 dollars. National City Bank gets its crew of nifty looking bond salesman and the talk is bruted around that National City is offering, 'as, if, and when' with all the proper phraseology and sleek looking salesman oiling the selling machinery. Result is National City sells its bond issue to a gullible public. Tom Citizen, a poor sucker who has a thousand dollars saved up from teaching school or tightening nuts on an automible [*sic*], goes in to what he thinks is a big, reputable house and he comes out with a Cuban bond yielding 6%, the interest on which raised in part by another bond issue.
>
> "Well this leaves National City with a fat profit of let us say 10,000,000 dollars and Public Works with 40,000,000 for the great highway. An American firm representative, used to Latin American road contracts is called in to conference and emerges with a fat contract. The secret figure which Mr. American gets is 50,000 dollars per mile, which is certainly plenty and then some. Of course Mr American bills Obras Publicas for 140,000 per mile and distributes the balance between *his* profit as entrepreneur and what he bills Public Works. The balance which you will agree is goodly is distributed among close members of the 'gran departmento de Obras Publicas.' Mr. American is paid promptly because as soon as he's paid the largess is distributed and memebers [*sic*] of Obras Publicas have hungry mouths to feed! So the great thing goes thru [*sic*]. Yawping [*sic*] tourists come down and see the nice carretera and beautiful capitolio and rave about how advance Cuba is. The debts pile up—they can never be paid, will eventually be repudiated. Who suffers? Tom Citizen, the gullible American citizen who believes in great big institutions, and the great mass of Cuban people who are deprived of essentials. Thus Joe President reduces teacher's salaries so that the interest on Public Works can be paid. Officialdom and National City Bank get big swigs at the 'botella' (bottle) whilst we eventually pay the price.
>
> "There you have it. I have no figures to back me up, other than the fact that the central highway which is a fair job, cost 140,000 dollars per mile. Compare this with costs in the States for an A-1 super-fine, reinforced concrete road with all sorts of emellishments [*sic*] (20,000 per mile would cover it) and you can see that something is damn rotten in Denmark." [Parentheticals and emphases in the original.][117]

Eventually the clouds of war overtook the world and letters from Harris' former students carried descriptions of war preparations as well as geological ones. Weisbord was working for Island Exploration company in Papua, New Guinea, in 1939, only six months before the beginning of World War II. Yet the war clouds did not dampen his spirits nor interfere with his recreation which included both old and new games:

> "Two days ago arrived a detachment of 40 Australian soldiers and several big guns destined for the protection of Port Moresby in event of war. A naval and air base is being established as well so that the place is developing, one way or another, quite rapidly and quietly.
>
> ". . . a suburb of Port Moresby, is the site of the technical staff. Fortunately it is located adjacent to the golf course, so that after hours I can get my swearing done early and keep at it until nightfall. Golf is a game, the emotional graph of which closely resembles a business chart with

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[117] Norman E. Weisbord to Gilbert D. Harris, November 3, 1931. HA-PRI, Ithaca, NY.

> long periods of depressing lows and brief peaks of soaring highs. It is a game unsuited to my temperament since it affects my sensibilities too much. Between strokes I run the whole gamut of reactions and since I am a duffer these reactions may make me apoplectic. . . .
>
> "In one of the weekly cricket matches I was given the opportunity of playing and, according to the local paper, 'delighted the crowd with my baseball antics.' You probably know as much about game as I do. I never handled a cricket bat before. You're supposed to keep the ball away from the wicket by smacking the ball before it hits it. Since the ball bounces first and comes with terrific speed and all sorts of twists it's not as easy as it looks. I hit a number of foul tips which to my surprise counted for runs so I rolled up a better score than some of the blokes who have been playing since childhood. Came a ball, however, which I missed and which knocked over the little ticks and did I feel sheepish. Still I got a good hand from the fine, sporting crowd who go a big kick out of my unconventional stance."[118]

No matter where they went, the former students continued to send Harris fossil collections whenever possible. This continued especially after he started the Paleontological Research Institution:

> "As a souvenir from New Zealand for the Paleontological Research Institution, I have sent you a fossil moa bone. I believe it is the fused tibia and tarsus or the lowest part of the leg which was covered with feathers. It belonged to the largest species *Dinornis maximum* and the bird in life probably stood almost 14 to 15 feet high"[119]

Thus consulting activities served as a valuable resource for Harris and his students. For the students these activities provided adventure, meaningful employment (especially during the depression years of the 1930s[120]), an opportunity to make a meaningful contribution to science, and, in some cases, the opportunity to explore the unexplored; to be true geological pioneers, following in the footsteps of other former Cornellians such as Hartt, Derby, and Branner. For Harris, the rewards came from advancing the understanding of Tertiary strata, building his fossil collections, and, as it turned out, the financial return. Apparently his consulting work allowed him to gradually build a nest-egg that could be used to start the Paleontological Research Institution in 1932. Without the financial rewards he reaped through the consulting activity, it seems unlikely that he would have had the necessary resources during the depths of the Great Depression to found his own institution.

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[118] Norman Weisbord to Gilbert D. Harris, March 26, 1939. HA-PRI, Ithaca, NY.

[119] Axel A. Olsson to Gilbert D. Harris, August 4, 1939. HA-PRI, Ithaca, NY.

[120] "Very soon now I shall have to decide whether to go away again (the Company wants me to return to the East when my time is up) or stay in the States as another member of the unemployed." Norman E. Weisbord to Rebecca Harris, September 21, 1939. HA-PRI, Ithaca, NY.

CHAPTER 7. CARLOTTA J. MAURY

One incident occurred between Harris and a former student which, when compared with his relationships with other students, appears to be totally out of character, and had a profound influence on his later life. The incident was a very serious affair for the student, for Cornell University, and for Harris. It may also have sown the seeds of distrust and discontent that, seven years later, would lead Harris to break completely with Cornell and found his own organization, the Paleontological Research Institution. It is therefore treated separately with considerable detail.

Before describing the disagreement Harris had with Carlotta Maury, however, it is useful to consider an earlier episode which, perhaps, sets the tone for what followed. The first record of a serious disagreement between Harris and an outside party comes from a note Albert W. Smith, Acting President of Cornell, sent to Heinrich Ries accompanied by a copy of a letter from Professor Junius Henderson at the University of Colorado at Boulder:

> "Since this is a question that may affect seriously the good name of the University I would ask you to take prompt measures to adjust the matter so that it is satisfactory to Professor Henderson."[1]

The "question" mentioned was this. In 1917, after corresponding with Harris, Henderson sent him a box of fossils from the western U. S. containing more than

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[1] Albert W. Smith to Heinrich Ries, July 7, 1920. Schurman Papers 3/4/6, v. 47, p. 263. Also a copy in the Heinrich Ries Papers 14/15/691. RMC-KL, Cornell.

150 species. In return Harris was to forward examples of New York Devonian fossils. There were receipts signed for the fossils and several letters exchanged, but Harris did not complete his part of the arrangement, and, according to Henderson, Harris would not even answer his letters. So Henderson appealed to the University President:

> "Cornell University has our material and it seems hopeless to make any further appeal to Professor Harris. I am told that he has treated other paleontologists in exactly the same manner. I do not believe he has any intention of being dishonest or unfair, and suppose he will justify his failure to keep his promises made on behalf of Cornell by saying that he has been too busy to attend to it, or something of that sort. Nevertheless, the effect upon those who have dealt with him is the same as if he had deliberately started out to steal their material, so far as actual results are concerned."[2]

Harris was out of town at the time Smith's note reached Ries, but upon his return, Harris wrote to Ries stating that he had received the 157 species and that Henderson wanted a similar sized collection of Devonian and Atlantic Coast Miocene fossils in return. He said that he had planned to have Axel Olsson put together the collection Henderson wanted, but Olsson left for a six-month stay in Panama that turned into two years. Olsson, however, had now returned and Miss Katherine van Winkle was there to help. Henderson's collection was right in front of him, "continuously in view", and the samples requested could be sent with, "justice to ourselves and satisfaction to Henderson." Harris continued:

> "So far as I am aware I have answered all communications rec'd [*sic*] from him and have tried my best to explain the delay and cannot understand his caustic imputations."[3]

This exchange with Henderson must have brought Harris' temper to the foreground; based upon Henderson's reply, Harris must have sent him a scathing letter, but no copy of it exists. Apparently Harris, among other things, asked for the list of people he had, ". . . treated the same way." Henderson was quite apologetic in tone, but stood his ground and did cite his source:

> "In the first place I have not intimated, as you say, that you have been swindling a long list of unfortunates these past years. Neither have I made any sweeping charge as to your general character, as you declare. I explicitly said that I did not believe you had any intention of being dishonest or unfair, and that you would doubtless explain the long delay by saying that you were too busy to attend to it. . . .
>
> "I regret that I cannot send you 'the long list of unfortunates' that I 'intimate' you have been 'swindling these past years,' for the very good reason that I have made no such intimation of a long list of unfortunates. I did say that I had been told that you had treated 'other paleontologists' the same way. I would very willingly give you the name of the man who told me that, but his name has escaped me entirely. . . . One of these geologists (I believe he was in the employ of the Toxana or Mid-West company [oil companies], though I am not sure) spent several hours here, and we got to talking incidently about exchanging material. In reply to his inquiry as to where we got certain unusual material I told him of some of our exchanges, and just incidentally remarked that I sent a lot to you for the purpose of getting some more Miocene and Devonian material, two or three years ago, but had not yet received the return collection because Mr. Olsson had been called away at that time. He began to laugh, and said that there were 'others' who had had the same experience: that he himself had sent you material some time before for which he had received no return. He had no thought of dishonesty on your part, he said. . . . If he deliberately lied to me, then you certainly know it. If he told the truth, then you of course know who he is."[4]

The incident related here is trivial, except that it does demonstrate the strong reaction that came from Harris when he thought he had been wronged. His temper does not show itself very often in the written records that survive or in the various personal anecdotal remarks, but this small incident certainly demonstrates its existence. Perhaps that temper played a role in the difficulty that developed about six years later with Maury. Certainly, given knowledge of the situation with Henderson, Harris' temper does manifest itself in his letters to her company.

The Maury incident began in 1925–26 over an alleged breach of confidentiality and ownership of samples kept on the fourth floor of McGraw Hall (Plate 11). Carlotta Joaquina Maury was working for one group of oil companies and Harris was a consultant to another. Maury was born in Hastings-on-Hudson, New York in 1872,[5] and lived there in the ancestral home of her mother, Virginia Draper Maury, for most of her life when she was not out of the country.[6] Maury lived the last two years of her life in Yonkers, New York.

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[2] Junius Henderson to President of Cornell University, July 7, 1920. Schurman Papers 3/4/6, v. 47, p. 264. Also a copy in the Heinrich Ries Papers 14/15/691. RMC-KL, Cornell.

[3] G. D. Harris to Heinrich Ries, July 29, 1920. Heinrich Ries Papers, 14/15/691. RMC-KL, Cornell.

[4] Junius Henderson to G. D. Harris, August 10, 1920. Heinrich Ries Papers, 14/15/691. RMC-KL, Cornell.

[5] Notes on her life are taken from her obituary in the *New York Times*, Tuesday, January 4, 1938, p. 23, and from *Who Was Who in America*, v. 1 1897–1942, p. 791, Chicago, A. N. Marquis Company.

[6] In the Harris Archives is an undated post card photograph of a very fine looking dwelling labelled "The Old Draper Homestead,

Her sister was Miss Antonia Coetana de Paiva Pereitra Maury, a former research astronomer at the Harvard Observatory.[7]

Contrary to the story which has circulated around the Cornell Department of Geological Sciences for many years, and repeated in the department history (Brice, 1989), Carlotta Maury was only distantly related to the famous oceanographer Matthew Fontaine Maury through her father's family; she was not his daughter or granddaughter. Her father, The Reverend Mytton Maury, D.D., the son of William and Sarah Mytton Maury, was born near Liverpool, England and came to the United States in 1849. Mytton's father, William Maury, was an English cousin of Matthew Fontaine Maury. Matthew Maury worked for the Confederacy in England during the Civil War. Unable to return to the United States immediately after the war, he lived in Mexico for a while and, with the help of Empress Carlotta of Mexico, he tried to organize and settle "New Virginia, Mexico." Eventually he did return to the U.S. in 1868 (Corbin, 1888; F. L. Williams, 1963). Aside from his oceanographic work and naval career, Matthew Fontaine Maury is best known for a series of school geography texts, Maury's Geographical Series. After Matthew's death in 1873, Mytton Maury, Carlotta's father, served as editor of these books from 1875–1895 (M. F. Maury, 1891).

After attending Radcliffe, Columbia University, and the University of Paris, Carlotta Maury came to Cornell and completed the Bachelor of Philosophy in 1896, but then, according to Harris, she left for a term or two:

> "Miss Maury, who spent a year in France after holding a fellowship in this department, has been unable for financial reasons to take her second degree this year, though she will soon fill all requirements for the same."[8]

She did, indeed, return and completed her Doctor of Philosophy degree in 1902. She was the first woman to obtain a Ph.D. degree in geology at Cornell, and was among the first women in the United States to earn a Ph.D. in geology[9]. Her thesis was published as Number 15, Volume 3 of the *Bulletins of American Paleontology* (C. J. Maury, 1902).

Right from their first days together as student and teacher, Harris and Maury appear to have developed a very close working relationship. One example of this can be seen from the work she did on fossils collected at a site along the western shore of Cayuga Lake, between Taughannock Falls and Frontenac Beach. Apparently the location was first noticed by Harris' colleague, R. S. Tarr. The site is now known as "Fernbank", a name whose origin is unknown and which is not included in any local history archive.[10]

Apparently while she was a student, Maury and Harris visited the site together, for the date, May 1897, is on the handwritten fossil identification cards.[11] In this small side valley along the shore of Cayuga Lake, Maury and Harris collected fossil freshwater shells that are of the same mollusc genera as found in the lake today. In 1908, Maury published a brief description of these shells, which were deposited during a warm interglacial stage when water in Cayuga valley was about 15–18 meters above its present level (C. J. Maury, 1908). More recent inspections indicate the lower part of the section to have been deposited during a high water, warm climate period. Then there was a short period of erosion, followed by high water again, but with a much cooler climate. Radiocarbon dating of the plant material in the upper portion has produced ages greater than 50,000 years. The site remains difficult for glacial geologists to explain because, although it correlates well with the Don Beds of Toronto, Ontario, it remains unique in the Cayuga Lake valley, and so far as is known, unique in the entire Finger Lakes region.[12]

Maury had a marvelous career after leaving Cornell and during most of this time her relationship with Harris was one of cordiality and mutual respect, at least if the following letter Harris wrote to Branner is typical:

> "I received with pleasure your note from Brazil last summer, and I believe Dr. Derby[13] has written my illustrious student [Maury] this summer of [*sic*] South Africa, if it may be possible to make the arrangements to have her

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200 Years Old—Hastings-on-Hudson" with the message, "Come see us. Carlotta." HA-PRI, Ithaca, NY.

[7] Antonia Maury was a colleague of William Pickering at Harvard Observatory and she did pioneering work in star classification by spectral analysis; eventually she published a catalog with the spectral classification for about 4800 stars.

[8] *Annual Report of the Department of Paleontology and Stratigraphic Geology*; 1899–1900, by G. D. Harris, p. 5. HA-PRI, Ithaca, NY.

[9] John W. Wells, Personal communication, July 15, 1982.

[10] Personal communication, Professor Arthur Bloom, Cornell University, June 22, 1995.

[11] One set of samples is in the possession of Professor Arthur Bloom at Cornell University. Who prepared the hand written identification cards is unknown, but the handwriting is very similar to Carlotta Maury's.

[12] For this brief summary, I am indebted to Professor Arthur L. Bloom, Cornell University, personal communication June 22, 1995, and the loan of a guidebook he and John H. McAndrews, Royal Ontario Museum, prepared for the "Friends of the Pleistocene", 35th Annual Reunion, May 19–21, 1972.

[13] Orville A. Derby (B.S. '73; M.S. '74), student and colleague of C. F. Hartt, did not have a Ph.D.

> come and look over the Museum at Rio Janeiro [*sic*] in the near future."[14]

Maury did develop a connection with Derby and the Brazilian Geological Survey, and several years later, Harris again wrote to Branner:

> "I note what you say regarding paleontological work for Brazil. Now it so happens that Dr. Morey [*sic*] has been doing a magnificent, great piece of work for the Brazilian Survey, and is thoroughly familiar with, presumably all, the horizons . . . ,and it seems to me that she is the logical one to take this work up [for pay] and put it through, as she is not at leisure to do this class of work. Her great monograph on the Brazilian fossils contains twenty-four large quarto-plates, and is certainly on a par with, and I think superior to, Clarke's[15] monograph on the Devonian of Eastern Brazil. If, however, the fossils were sent here, and she, for any reason, should be obliged to leave the work unfinished, I will guarantee that it will be taken care of at once by competent hands here in the laboratory."[16]

Harris wrote to Maury after she had been to Brazil and returned to South Africa where she was teaching at Huguenot College:

> "Feb. 9, 1914
>
> "Miss C. J. Maury,
> Huguenot College,
> Cape Province,
> South Africa.
>
> "My dear Miss Maury:
>
> "Your letter from Los Palmos was received today and am greatly pleased at the scientific spirit shown therein. You can depend on me for your illustrations—the more the better; and in case the Brazilian Survey has no funds, I shall do it just as cheerfully without. Moreover, it seems to me that in case the Revolution is on you could send your material and descriptions of species and I could get them out carefully as a Bulletin of American Paleontology. In this case your work would not be buried, Revolution or no Revolution.
>
> "As to illustrations, I have got me a large, six-foot $130. camera and am using it almost exclusively in my illustrations now-a-days, and before you finally decide on your illustrations I shall hope to send you copies of photographic reproductions that may suit you even better than line drawings.
>
> "It seems strange that you should be in South America and should find so many acquaintances and friends, and most of all I was astonished to note the mention of Pacheco, and I wonder if the Crandalls are any relatives of the Crandalls here. This is interesting to me as my own mother's name was Crandall. I hope to see them here some time.
>
> "This must be, on account of haste, a business letter, and I will write you the gossip at some future time.
>
> "Yours very truly,
> [unsigned]
>
> "GDH/MEH"[17]

Upon her return to the United States from South Africa, Maury was awarded the Sarah Berliner Fellowship in Biological Sciences,[18] created by Mr. Emile Berliner of Washington, D. C., in memory of his mother, Mrs. Sarah Berliner , ". . . a woman of strikingly strong and noble personality." (C. J. Maury, 1917a, p. 165). The Fellowship included a cash award of $1,000.00:

> ". . . for studying some biologic science at any university or museum, here or abroad—provided a definite line of study be undertaken and a report upon the results of the same be produced. (Anonymous, 1917, pg. 434)

Maury chose to spend part of her money mounting an expedition to the Dominican Republic, for there had not been any new collections made of the island's fossils in over 40 years (C. J. Maury, 1918). Personnel on the expedition included two veterans of the *Ecphora* trips: Karl Paterson Schmidt[19] and Axel A. Olsson[20]; both, ". . . had the great advantage of having been trained in geological field work by Professor Gilbert D. Harris, . . ." Maury received additional money to pay for an extra assistant from the Veatch Fund for paleontological research at Cornell which was mentioned earlier. Harris outlined the arrangement for Ries in a leave request for Olsson:

> "Will you kindly see that the proper authorities are consulted and the necessary arrangements made for a leave of absence for Mr. Olsson from about May to the end of this term in order that he and Mr. Schmidt may carry out the roughest part of the San Domingo work. . . . Dr. Maury will have general charge of the expedition, going for a short time in June personally, [she] will contribute $300 [for them], whereas I shall turn over $200 of the Veatch fund for the boy's use. This will give them $500 in cash wherewith to collect in Gabb's[21] old localities and make sections

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[14] Unsigned carbon copy, Gilbert D. Harris to John C. Branner, October 4, 1913. HA-PRI, Ithaca, NY.

[15] John Mason Clarke (1857–1925), State Geologist for New York.

[16] Unsigned carbon copy, Gilbert D. Harris to John C. Branner, October 3, 1921. HA-PRI, Ithaca, NY.

[17] An unsigned carbon copy of the original, but with Harris' initials at the bottom; Gilbert D. Harris to Carlotta Maury, February 9, 1914. HA-PRI, Ithaca, NY.

[18] In a letter to Heinrich Ries, Jacob Schurman used the title, "Sarah Berliner Research Fellowship for Women." February 28, 1916. Heinrich Ries Papers, 14/15/691, Box 1, File 1-24. RMC-KL, Cornell.

[19] Schmidt was member of the *Ecphora* expeditions.

[20] Olsson was an instructor at Cornell at the time of the expedition.

[21] William Gabb who had collected and written about the fossils on Santo Domingo in 1873. See C. J. Maury (1918).

> wherewith to determine the true sequence of Tertiary fauna of the West Indian region, ... There is a splendid chance here for Dr. Maury and Cornell to distinguish themselves in Tertiary investigation—and the means (money, strength, brains) are at hand. Now seems the time. [Parenthetical in the original.]"[22]

From this letter, as the two men were going in May and Maury wasn't scheduled to arrive until June, it would seem Olsson and Schmidt were going to be doing field work on the island before Maury arrived.

Maury acknowledged their contribution to the expedition:

> "All the heavy and arduous work of collecting was done by Mr. Schmidt and Mr. Olsson. This involved wading up rivers, carrying heavy packs of fossils, sleeping in the roughest shanties, and undergoing the greatest discomforts, some not unmixed with danger to health and life, but none causing them to falter in the slightest degree." (C. J. Maury, 1917a, p. 167).

For three weeks all went well, but then the work was brought to an abrupt halt by yet another revolution that ". . . assumed menacing proportions." (She seemed to have had her problems with revolutions, first Brazil and now the Dominican Republic.) She described the situation this way:

> "The party arrived at Monte Cristi none to [*sic*] soon, as the Revolutionary party had begun shooting. All Americans took refuge on the United States gunboat *Panther*, and remained on board four days.
>
> "The Dominican residents who did not join the rebels fled to the beach. The town was deserted, the bush full of rebels, bandits and *malo gente*. A return to the field from the direction of Monte Cristi was obviously impossible.
>
> "Proceeding on to Puerto Plata we hoped to strike in from there to Santiago, as under normal conditions a cogwheel railroad connects these towns. But Desiderio [Desiderio Arias, the leader of the revolutionary forces] had captured all the locomotives. Moreover we met at Puerto Plata the American residents of Santiago as refugees who had left all their possessions and secretly fled under cover of night. Several had hidden in the bush without food for some days. Conditions in the interior were such that we were most urgently advised to abandon the attempt to reach Santiago, since Desiderio was entrenched there, and geologizing in the lonely thickets would certainly result in our being shot and never heard of again. The sight of seven dead men on the pier at Macoris convinced us that this was no idle fancy. So with profound regret we were forced to abandon the Santiago section and the study of the blue clay of the Upper Yaqui and Nivaje, but we trust that we may yet accomplish this on a future occasion." (C. J. Maury 1917a, pp. 173–174).

Axel Olsson and Karl Schmidt added to the story; when they were cut off from the rest of the party by the revolution, they managed to get through the rebel front lines by speaking German and pretending to be from Germany rather than from the U.S. (Moore, 1978). This time being "German" was an asset for Olsson; only two years before he had been arrested as a suspected German spy while on the second *Ecphora* field trip with Harris in the Carolinas.

Even after escaping the flames of revolution with her samples, Maury's troubles were not over. She returned to Cornell during the winter and spring of 1916–1917:

> "No sooner was work begun on her collections than it was discovered that materials of a similar character, from the same island, collected forty years ago, would be shortly studied and reported upon [by Pilsbry and Johnson], thus forestalling her in her work and relegating her types and descriptions to the scrap-heap of synomymy [*sic*].
>
> "Weeks and months of strenuous work ensued until finally a work of 300 pages of printed matter and 40 plates was brought out by the privately-owned press in the geological department of Cornell University four days before the rival work was issued! The specific names proposed for the types described by Dr. Maury will therefore ever hold as true names for these life forms and the great and valuable collection will doubtless eventually become property of the University if fire proof accommodations are provided for its reception." [Emphasis in the original.] (Anonymous, 1917, p. 434).

Maury herself described the situation in these words:

> "Since publication and distribution of Bulletin of American Paleontology, No. 29, Sections 1 and 2, comprising the systematic discussions of our Santo Domingo fossils, quite a number of Gabb's 1873 shells in the Philadelphia Academy's collection have been described, without figures, as new species by Drs. Pilsbry and Johnson.[23] No doubt a number of these are not represented in our collections and should be added to the Santo Domingo fauna. Some species, however, described as new by Drs. Pilsbry and Johnson will prove identical with mine and will pass in synonymy, since mine have priority. For, Section 1 (pages 1–120[24]) of Bulletin 29 was published and distributed March 31, 1917 and Section 2 (pages 121–240), April 29, 1917, while Drs. Pilsbry and Johnson's *Advance Descriptions* were not issued until May 4, 1917, as stated on the cover of their separates." (C. J. Maury, 1917b, p. 419).

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[22] G. D. Harris to Heinrich Ries, March 30, 1916. Heinrich Ries Papers, 14/15/691, Box 1, File 1-24. RMC-KL, Cornell.

[23] Original Footnote: "New Mollusca of the Santo Domingan Oligocene, Proc. Acad. Nat. Sci. Phila., designed for the April number which was not issued in April. Advanced separates issued May 4, 1917."

[24] Note that until Volume 36, Number 155, *Bulletins of American Paleontology* had two different sets of page numbers. One referred to the issue or number, and another the entire volume. Here Maury is referring to the page numbers of the issue. The cited reference uses the volume page numbers.

The type specimens from this expedition are now in the PRI collections.

The following year the Harris-Maury relationship continued on the same level of cordiality and respect, albeit with some indication of tension over the funding of her work. Knowing what was to follow, this seems to be the first hint of trouble. Maury wrote to Harris about expenses incurred in obtaining some fossils from Africa. This excerpt from her letter also illustrates the difficulties encountered in obtaining such samples and what had to be done to move them from the field site to the laboratory collection.

> "Replying to your letter I would say that the expenses to be paid on the East African fossils are:
>
> (1) Transportation from outcrop in wilderness to the port which I think was Durban. Due to Dr. F. B. Thompson, Bizara, Pondoland, East.
>
> (2) Shipment from the East coast port to Cape Town.
>
> (3) Transportation by rail from Cape Town to Wellington where the fossils were stored a year for safety.
>
> (4) Transportation by rail from Wellington to Cape Town.
>
> (5) Shipment from Cape Town to Boston.
>
> (6) Transportation from Boston by rail to Ithaca.
>
> Miss [illegible] has kindly paid (2),(3),(4),(5),(6) and this loan is to be refunded to her, also any additional expenses she may have incurred. She will tell you the various amounts. I do not know at all what they were. We are greatly indebted to her for advancing the money and taking all the trouble.
>
> "As regards (1) Dr. Thompson who collected the fossils was most kind and did not charge for all this work nor would he tell me the cost. But I am sure it must have been several pounds and I am sure some such amount should be sent to reimburse him. . . .
>
> "I left with you all the important literature on the Bokkveldt, Port Elizabeth and Pondoland fossils. I was never reimbursed for those pamphlets, which amounts to 10 or 12 dollars, but will present them to your department. I also give my work and various expenses connected with obtaining the fossils as I have no doubt the expenses of transportation will use up or exceed the $50 remaining of the $100 appropriation[25].
>
> "I presume you remember that $50 only was placed in my hands and of that I presented an accounting several years ago."[26]

The first definite record of a problem between Maury and Harris is in a letter to Harris from Avery D. Andrews acting for un-named oil companies. A later letter in this sequence carries the letterhead of "The Caribbean Petroleum Company" and was signed by W. B. Pardee.[27] Andrews' letter, dated September 2, 1925, was in reply to a previous letter from Harris, of which no copy survives:

> "Please pardon our delay in replying to your letter of June concerning the paleontological work which Dr. Maury has been doing for our companies in Venezuela; but correspondence with both London and Venezuela has been necessary in order to reply definitely to your suggestions.
>
> "In the first place I wish to assure you that Dr. Maury has been acting in accordance with the original instructions and agreements made many years ago when our work was commenced in Venezuela. At that time we were the pioneers, and naturally wished to maintain the utmost secrecy concerning our work. Now that the Venezuelan fields are more widely known, we are willing to modify our arrangements somewhat, and suggest that the following procedure can be adopted if it appeals to you as satisfactory.
>
> "We propose that in the future fossils forwarded to Dr. Maury shall be sent as far as possible in duplicate, and that after her study is completed and reports made, one of each duplicate may be retained by Cornell University as a loan from the particular Company furnishing the fossils. A list of such fossils so loaned should be furnished us from time to time, and it should be quite clearly understood that the transaction is entirely in the nature of a loan, and that all such fossils remain the property of the particular Company from whom they are received, and subject to return to that company when desired.
>
> "All other terms and conditions of our arrangement with Dr. Maury remain unaltered, and I particularly invite attention to the agreement that no information accruing from these fossils so furnished will be published without our specific knowledge and consent.
>
> "If this agreement meets with the approval of Cornell University, we shall be glad to put it into effect upon receipt of appropriate advices from them"[28]

Apparently Harris did not reply, and a few weeks later, Andrews wrote:

> "On September 2 I wrote you concerning the Paleontological work which Dr. Maury has been doing for our companies in Venezuela. Not having received a reply, I fear that my letter may not have been received. I have no

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[25] The $100 was an appropriation from the Cornell University Trustees to Harris for obtaining South African fossils from Maury, but Harris had given her only $50 of the appropriation. This information is contained in a letter from Heinrich Ries to Gilbert D. Harris, November 11, 1915, and two days later Harris informed Ries that the South African material had arrived. Gilbert D. Harris to Heinrich Ries, November 13, 1915. Heinrich Ries Collection, 14/15/691, Box 1, File 1-24. RMC-KL, Cornell.

[26] Carlotta Maury to Gilbert D. Harris, February 5, 1918. HA-PRI, Ithaca, NY.

[27] From about 1914 until the 1920s, Harris was a consultant to an oil company in Louisiana which was part of the "Pardee Land Company, Philadelphia, Pennsylvania". There may have been a connection between that earlier company and the W. B. Pardee of the Caribbean Petroleum Company, but unfortunately the signature on the letters cannot be read.

[28] Avery D. Andrews to Gilbert D. Harris, September 2, 1925. HA-PRI, Ithaca, NY.

> desire to hasten your conclusions, but would be glad to know whether my former letter was received and that the matter is receiving your consideration in due course."[29]

There is no known immediate reply to Andrews' second letter either, but Harris did respond the following March, about six months later:

> "I have been looking after the material you sent me some time ago, hoping to be able to hit upon the exact horizon from whence your material was derived; but so far without success. Since it is all practically new no very definite correlations can be made. But, I shall soon send you a complete account of the paleontology of the macroscopic forms, and the plates can be used in the field for further collection and correlation."[30]

Harris then gave brief descriptions of several fossils in the collection sent by Andrews; including representatives of the genus *Rimella* which he said were, "The most striking molluscs in your collection . . ." It is noteworthy, however, how late Harris was with his response and, more importantly, that his letter said nothing about the need to keep a duplicate set of the fossils at the University. Later this was to become quite important.

In November of 1925, from Hastings-on-Hudson, Maury wrote a letter to Harris which seems to suggest their relationship was still cordial:

> "Dear Professor Harris:
>
> "Your letter gave me a real thrill, think of our seeing the *Opus*[31] with our mortal eyes! A hope long since abandoned!
>
> "As I am boarding for the time being in Yonkers [probably with or near her sister], it would be best if you would be so kind as to send the package on to me at: *119 Locust Hill Ave., Yonkers, N.Y.* But Hastings-on-Hudson is best for a permanent address when writing from time to time.
>
> "If the package is in a bad condition perhaps, if you asked one of the boys, like Weisboard [*sic*] or Olsson,they and Mrs. Palmer[32] would be so good as to put on an extra wrapping to protect it safely hither.
>
> "I should have liked very much to have seen Mr. Olsson.
>
> "Isn't it fine about the Bulletins! I should think the British Museum author on Madagascar ammonites[33] would be quite a feather in your Bulletin's cap.
>
> "Best regards and thanks. Sincerely always,
> Carlotta J. Maury [signed]"
> [Emphasis in the original.][34]

The dedication in the "Opus" she mentions further indicates the close professional relationship she had with Harris and the respect she had for him and his work:

> "TO THE PUBLISHERS OF THE
> BULLETINS OF AMERICAN PALEONTOLOGY
> AND
> PALÆONTOGRAPHICA AMERICANA
> DEDICATED BY THE AUTHOR
> WHO HAS WATCHED WITH ADMIRATION THE MAKING
> OF THESE PUBLICATIONS
> FROM THEIR INTREPID INCEPTION
> TO THEIR PRESENT SUCCESS:
> WORKS FOR THE ADVANCEMENT OF PALEONTOLOGY,
> ORIGINAL AND FEARLESS
>
> *Anno amicitiæ tricesimo*"
> (C. J. Maury, 1925, Pg. 157)

This peace and tranquillity, however, lasted only another year. The following December Maury was at Cornell working on samples from the same oil company that had earlier sent samples which Harris had identified. While at Cornell she received a copy of a letter that W. B. Pardee, Assistant Secretary for "The Caribbean Petroleum Company" [at the same address as Andrews] had written to Harris in reply to a letter from him (no copy known):

> "With reference to your [Harris'] letter of November 30th, it is our understanding that Dr. Maury has in several instances sent specimens of fossils to different authorities in order to obtain as much data as possible but, in all cases, the specimens have been returned.
>
> "There apparently has been some misunderstanding in regard to the return of specimens for as stated in our letter of November 19th, it is our desire to assist the Cornell University laboratory as much as possible and we certainly would not discriminate against Cornell. We regret the unpleasantness that this apparent misunderstanding has caused but trust that matters will rectify themselves and

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[29] Avery D. Andrews to Gilbert D. Harris, September 25, 1925. HA-PRI, Ithaca, NY.

[30] Unsigned carbon copy, Gilbert D. Harris to A. D. Andrews, March 6, 1926. HA-PRI, Ithaca, NY.

[31] "*Opus*" probably refers to her 250 page paper on the paleontology of Trinidad (C. J. Maury, 1925).

[32] Norman E. Weisbord (A.B.'24, M.S.'26), a student of Harris who went on to work with various oil companies, *e.g.*, Standard Oil Company, Atlantic Refining Company, and Mobil. He spent many years while with these companies working in South America and the Caribbean. He became a professor of paleontology at Florida State University in 1957. He was a charter member and great friend of PRI. Katherine V. W. Palmer (Ph.D.'25; 1895–1982), also a student of Harris', a founding member of PRI and was present at the laying of the corner stone. She was also the second director of PRI.

[33] Spath (1925).

[34] Carlotta J. Maury to Gilbert D. Harris, November 19, 1925. HA-PRI, Ithaca, NY.

> that there will be no further trouble in regard to the fossils."[35]

Harris did respond to Pardee's letter, but apparently not to Maury herself. A copy of that reply was forwarded to Cornell President, Livingston Farrand, and to Heinrich Ries, Head of the Geology Department. Harris told the company:

> "Caribbean Petroleum Company
> Messrs:
>
> "Referring to the subject over which we now have had considerable correspondence let me state that over a year ago I informed you that I did not consider it proper to send materials here to be looked over and reported upon without conforming to the regulation practice of having it proper [*sic*] labeled and a provision for a duplicate set to remain here for general reference work. You have seen fit to send here a large collection of fossils without my consent and have directed Miss Maury to work it up here. Fortunately we have no objections to Miss Maury personally. But you are taking advantage of help and conveniences here and wholly ignoring just obligations.
>
> "The term ends December 18th and I am asking that you have all packed and shipped by that date as I shall not allow work to go on here of that character beyond that date. If in the future you will conform to the regulations above noted I shall of course do what I can to help you along just the same as with others. And, if I receive your reply within 48 hours stating that you will conform strictly to the above mentioned conditions your specimens will be cared for till the 18th, otherwise I shall not hold myself responsible for whatever may happen to the material.
>
> Yours as always
> G.D. Harris"[36]

Note the reference to the "duplicate set" in his response. When Harris had examined a set of fossils for the same company earlier, and discussed that work in his letter of March 6, 1926, there was no record or mention of any request for a duplicate set of the fossils to be added to the collections in his laboratory at Cornell. Apparently, he was now expecting Maury to do something he did not do himself when he examined fossils for the same company.

Others working on oil company material in Harris' laboratory at the same time apparently did not disclose detailed information about the samples. Note the similarity of the disclaimers, especially the second and third ones:

> "This article is based on more than two years of field work in Venezuela unraveling the stratigraphy and paleontology of certain areas for one of the American [oil] companies operating in that country. We propose here to describe some of the new material collected during this investigation with general reference to type localities and general age determination.
>
> "At some future time when interests of the company for whom the work was done permit, we hope to publish more definite information as to the exact locatity [*sic*] of each collection, the type sections, and the stratigraphic range and age determination of the species described." (F. Hodson, 1926, p. 173)
>
> "Only descriptions of species with general localities and general ages can be given at present, but later when the interests of the company permit, we hope to publish definite localities and stratigraphic ranges for the species." (H. Hodson, 1926, p. 2)
>
> "The collections upon which this article is based were made in Venezuela for an American company. Only descriptions of species with general localities and general ages can be given at present, but later when the interests of the company permit, we hope to publish definite localities and stratigraphic ranges for the species." (Hodson *et al.*, 1927, p. 2)

A further aspect of this issue is related to Harris' own private geological work, details of which have been given in another section. Starting in 1921, Harris was employed as a consultant by several oil companies for work in Trinidad (Trinidad Petroleum Development Company, Ltd.) and Venezuela (Standard Oil Company of Venezuela, for which both Hodsons worked)[37]. But aside from that one time when he did the identification work mentioned previously, Harris does not seemed to have been employed by The Caribbean Petroleum Company. Given the situation, at the very least, this is a major conflict of interest.

Maury's company response to Harris' demand went to her by telegram, and sent in care of the Paleontology Laboratory at Cornell:

> "Miss Charlotta [*sic*] J. Maury
> Paleontological Laboratory
> Cornell Univers., Ithaca, N.Y.
>
> "Prof. Harris has written us giving notice that unless within forty eight hours we agree to certain conditions he will not be responsible for anything which may happen to our fossils and materials now in his laboratory stop we therefor [*sic*] request that you finish your examination and remove

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[35] W. B. Pardee to Gilbert D. Harris, December 2, 1926. HA-PRI, Ithaca, NY.

[36] A copy of the letter dated December 6, 1925 from Gilbert D. Harris to the Caribbean Petroleum Company is in the Heinrich Ries papers, 14/15/691, File 1-23, and another copy is in the President Livingston Farrand Papers, 3/5/7, Box 20, File 20-51. RMC-KL, Cornell.

[37] Another former student, Axel Olsson, was working for Sinclair Oil Company at this time and he used the laboratory facilities whenever he had company samples to identify.

> all materials at the earlies [*sic*] possible date and not later than december [*sic*] eighteenth the end of the present term stop we are telegraphing Prof. Harris as follows quote your letter December sixth just received we will consider your proposals and remove our materials as soon as practicable but with regard to your forty eight hour ultimatum please take notice that for any loss or injury to any of our materials in your possession we will hold you personally and Cornell University strictly responsible in damages unquote please keep us advised by wire
>
> "Caribbean Petroleum Company
> "8 5 6 A. M."[38]

Harris replied to the telegram on December 9 by letter:

> "Caribbean Petroleum Co.
>
> "Messrs:
>
> "Your Postal Telegram of yesterday was duly received. I note with surprise my, and the University's responsibility over your collection, sent here contrary to my wishes at least under conditions I have never agreed to. This is a new angle, but I accept it with of course proper compensation. Your material has been here now occupying space, you have been furnished heat, light, library and museum facilities for some and whatever any competent committee should judge these facilities worth, I am willing to accept[.] Perhaps $100.00 per months [*sic*] would not be excessive. Please let me hear from you before the removal of your collection and greatly oblige[.]
>
> "Yours always
> "G.D.Harris"[39]

It is not hard to imagine the confusion reigning in the fourth floor paleontology laboratory of McGraw Hall, with Harris sending letters to and receiving telegrams from her company, and Maury trying to do her work while getting telegrams telling her to pack up and clear out, and all the while evidently having little, if any, communication with Harris. Based on statements in a letter by Ries, quoted below, very little of what was passing between Harris and her company was being communicated to her by Harris. She was apparently hearing enough, however, to feel very pressured. Finally, perhaps in desperation, on December 10, Maury turned to Heinrich Ries, Head of the Department of Geology, in a letter on which she gave the department as the return address:

> "My dear Prof. Ries:
>
> "May I lay before you as Head of the Geological Department of Cornell University, a matter which relates to the University policy towards commercial companies that are carrying on research in the University's laboratories? I wish also to protest against Prof. Harris' threat to eject the material of the company that I represent within 48 hours unless the conditions he imposes are agreed to.
>
> "The company I represent has always been most courteous in its attitude towards the University, and desirous of returning any favors possible in recognition of the privilege of using from time to time the books and fossils necessary for identifying their fossils. A very important collection comprising the first lower Eocene material ever found in the entire Caribbean and Northern South American region was presented to the Geological Department by them some years ago. Were it possible, this depositing of duplicate, labeled sets and types in the University laboratories would have been continued and a few weeks ago, the company asked me to deposit duplicates of the fossils upon which I am now working.
>
> "But I wrote back advising most strongly against this-because [*sic*] I saw that my company was to be betrayed. The University was being used as a decoy to capture a very important set of fossilsfor [*sic*] the use of another company whose interests lie in the same field.
>
> "It is a fact obvious to all that this other company is using as its laboratory the paleontological research laboratory of the University, practically to the exclusion of everyone else. The students are perfectly aware of this and I have heard it much criticized.
>
> "As far as I am concerned I took both my degrees at Cornell. My Dominican collection is deposited here, also the Eocene I spoke of, and many casts of my Brazilian types. I have held two fellowships, one of the University, one from outside, but the work was done here. I cannot but think that the books I have published coming out from this Department have given credit to the University, notably my Monograph for the Brazilian Government, but others as well. Indeed you cannot take up any work on the Tertiary of the Caribbean or Northern South or Central America, without seeing constant references to the work I have done.
>
> "In token of my affection for the University, for years I have left in my will a legacy of ten thousand dollars.
>
> "I mention these details so you may know that I am not merely using the University's laboratory and giving nothing in return.
>
> "I know I am here now only by courtesy of the University, but I wish to ask why, if the University grants the privilege of research here to one Commercial Company, it should deny it to another? Why should one company be granted an entire laboratory for a year, and another be denied the use of a table for a few weeks? Why should one

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[38] Copy of a telegram (night letter)from Caribbean Petroleum Company to Carlotta Maury, December 7–8, 1926. Original in Livingston Farrand Papers, 3/5/7. Box 20, File 20-51; copy in Heinrich Ries Papers, 14/15/691, File 1-23. RMC-KL, Cornell.

[39] Letter from G. D. Harris to Caribbean Petroleum Company, December 9, 1926. A copy is in Livingston Farrand Papers, 3/5/7, Box 20, File 20-51, in Heinrich Ries Papers, 14/15/691, File 1-23. RMC-KL, Cornell. Also, an unsigned carbon copy on "Paleontological Laboratory, Cornell University" letterhead, is at PRI. HA-PRI, Ithaca, NY.

> company have the right to say to another, if you do not give me your fossils all labelled for my use in the field in which we are rivals, they will be confiscated!
>
> "Very truly yours,
> [Signed]
> "(Carlotta J. Maury)"
> [Emphasis in the original.][40]

Accompanying Maury's original double-spaced letter in the Ries files is a badly typed single-spaced copy, perhaps typed by Ries himself to keep this problem from reaching the department secretary (for obvious reasons), and at the bottom of page two of the copy is, "P.S. I enclose Prof. Harris' letter to the company and their telegram reply to me." Apparently Ries made the copy for President Livingston Farrand and included those items with the copy, all of which were forwarded by Ries to President Farrand.[41] This letter from Maury may have caught Ries by surprise and he may not have been very well informed as to what was happening only a few floors above him. This would be a reasonable assumption, considering the very strained professional and personal relationships that existed among the departmental faculty.

In the Ries papers is a small un-signed and un-dated note in Ries' handwriting. It appears to be the text of a telegram sent to the Caribbean Petroleum Company either just before or after he received Maury's letter. Determining who really instigated the telegram is complicated by the fact that both Ries and Maury had residences on Eddy Street in Ithaca at this time. The telegram read:

> "Please wire me (Eddy Street address) copy of letter by Prof. Harris containing stipulations referred to in first paragraph of his letter of Dec. six, nineteen twenty six." [the word stop written and crossed out.][42]

Given the fact that Ries included the company reply to his telegram with the material he gave the Cornell President, he may have been working on the situation before Maury's letter reached him. Ries' letter to the University President, which accompanied his copy of Maury's letter to him, is dated December 11, only one day after Mary sent her letter to Ries. The quotation given below is from the original letter Ries sent to Farrand. Annotations are added from what appears to be a draft of this letter which is with the Ries Papers. In places the draft has slightly different wording from what he sent to Farrand. Again, it appears Ries was typing his own letters to avoid using the department secretary.

> "My dear President Farrand.
>
> "I [Ries] submit herewith a protest received from Dr. Carlotta J. Maury, relating to her treatment in the Paleontological Laboratory, as well as several communications bearing on the matter.
>
> "This case is brought to your attention on the advice of Dean Ogden, as it involves important matters of University policy and also unfortunately presents other serious aspects.
>
> "Some explanation of the situation is necessary in order that you many better understand the conditions, although the bearing or significance of all the facts stated may not be clear until after you have read the attached communications.
>
> "The Paleontological Laboratory of Cornell contains a remarkably fine collection of Tertiary fossils, many of them type specimens ["species" used in the Ries copy]. I have always assumed that there was no objection to persons using it for consultation and reference, and I do know that some of our graduates who have been engaged in field work for oil companies, have brought their fossil collections back to Ithaca, and individually have spent several months at a time identifying [their specimens]. I have never heard of their being charged for this privilege.
>
> "I understand that Prof. Harris has done considerable work for the Stand Oil Company [Standard Oil] or its subsidiaries. There is of course no objections to this. [The last phrase was left out of the typed copy in the Ries Papers.] Further more for over a year Mr. Hodson[43] and his wife, assisted at times by a stenographer and others have practically monopolized the working space in what is known as the Research room of Prof. Harris' quarters. They have been engaged in working up fossils which they collected in Venezuela for an oil company, said to be Standard. During this period they have worked days and nights, have used any quantity of electricity and water, and so far as I know their company has not paid the University one cent for the privilege, Moreover to facilitate their work electric wires for lights, etc. had been strung in such a careless manner that the insurance inspector reported it. These were altered at the University expense.
>
> "I once asked Prof. Harris if Hodson's company was going to leave with the University a named duplicate set of fossils, and was told that he 'supposed' they would, but he did not state that the privileges extended oil representatives were conditional upon their giving the Department a set of duplicates.
>
> "Hodson's Ph.D. thesis was on the genus Turritella, the specimens of which were collected by him during his work

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[40] Carlotta J. Maury to Heinrich Ries, December 10, 1926. Heinrich Ries papers, 14/15/691, File 1-23. RMC-KL, Cornell.

[41] Badly typed copy of Carlotta J. Maury's letter to Heinrich Ries is in the Livingston Farrand Papers; 3/5/7. Box 20, File 20-51. RMC-KL, Cornell.

[42] Heinrich Ries Papers, 14/15/691, File 1-23, RMC-KL, Cornell.

[43] Floyd Hodson (Ph.D.'26) and Helen Kind Hodson, charter members of PRI. For examples see F. Hodson (1926), H. Hodson (1926), and Weisbord (1926).

for the oil company in Venezuela. I was a member of his graduate committee, and after examining his thesis commented on the fact that although he had described a number of new forms, there was no definite information regarding the localities or horizons from which they came.[44] Mr. Hodson explained this by saying that the company for which he was working had not yet obtained control of the property from which these fossils came, and that consequently for commercial reasons they did not want this information made public.

"I [Ries] mention this because Hodson's and Miss Maury's companies are rivals, working in the same general region (Venezuela), so that if Hodson's company considered it proper to suppress this information, and no objection seems to have been raised against it by Prof. Harris, it seems a little curious that the Caribbean Company should be criticized for doing what is somewhat the same thing. In other words if the latter deposited its specimens labeled as to locality and horizon in the collection it might be very useful for Hodson's company.

"The following facts have been given me by Miss Maury. During the past sixteen years Miss Maury has had approximately 8 boxes of fossils sent her by the Caribbean Company for identification. She had deposited here one large collection which she worked up for the predecessor of her present company.

"The 8 lots referred to above, had few or no duplicates and consequently no extra collection could be left. Although Prof. Harris expressed a desire to get duplicates of the fossils which Miss Maury worked over, he never made any stipulation to her. Moreover all his communication to her company have been sent without her knowledge.

"In the winter of 1925–26, while Miss Maury was in Egypt, the Caribbean company, not knowing that she was away, sent a box of fossils addressed to her at Ithaca. Prof. Harris saw the box and wrote to the company suggesting that he could do the work[45], This he was allowed to do, and was paid for it. So far as Miss Maury knows he retained no duplicate set.

"About May or June 1926 the Caribbean Company advised Miss Maury that another box of specimens had been sent to Ithaca for her to identify, so she came up here and worked on it. No set of duplicates was available to leave here, and Prof. Harris raised no objection.

"In October 1926 Miss Maury came here to work up another small collection. This material fills a box about 20 × 18 × 18 inches. In working it up she occupies two small tables over which there hung one electric light. She has not used over ["not" and "over" scratched out in the Farrand copy, but left in the typed copy in the Ries Papers] about 12 books for consultation, not over 6 of which belonged to Prof. Harris. There were very few duplicate specimens in this last lot of material sent, and the collection has been returned to N.Y. City. The [These] data given in this last paragraph have a bearing on the statements made in Prof. Harris' last letter.

"I am informed also by Miss Maury that in this last piece of work she has referred chiefly to her own collection from San [*sic*] Domingo which she presented to the University. She has for ethical reasons been careful not to look at the material collected by Hodson but she has noticed in passing by the specimens are identified merely by numbers or signs.

"I have given you above such facts as are in my possession, and which it seems to me have some bearing on the attached letters. As the matter is a serious one involving University policy towards commercial companies, I feel that it deserves being called to your attention. Prof. Harris will no doubt wish to explain his attitude, and I think he should be given an opportunity to, Miss Maury also stands ready to answer any questions you may wish to ask her.

"It is gratifying to feel that Cornell possess a paleontological collection sufficiently valuable to be regarded as [the "as" is missing in the copy in the Ries Papers] a standard for reference, and I believe that all workers should be given equal privileges to consult it so long as the University rights are properly safeguarded, and it involves no interference with the work of our regular students, either graduate or undergraduate. I cannot see however that the representatives of any one company should be allowed to enjoy a monopoly.

"It is also to be regretted that any member of the faculty should appear to demand personal compensation for the granting of privileges which do not belong to him, as such action cannot fail to be prejudicial to the reputation of the Department and also the University.

"Yours very truly,
[Signed] H. Ries"[46]

While Ries was sending his letter to Farrand, Maury received the following from Avery D. Andrews, dated December 10:

"Many thanks for your letter of December 9th just received. While the Caribbean Petroleum Company does not itself care to make any complaint against Professor Harris, we certainly have no objection to you, as an Alumnus of Cornell, placing such facts before the Authorities as you may desire.

"In this connection, I have just received a further letter [December 9, 1926], presumably from Professor Harris. The signature is typewritten and over it are the penciled initials 'G.D.H.'. I enclose a copy of this letter which is exact in all particulars, including punctuation. I mention

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[44] This work was published without listing any localities (F. Hodson, 1926). The list of localities was kept separate and never published; it is in the PRI archives.

[45] Harris' letter of March 6, 1926 about this work is quoted earlier; see page 21.

[46] Heinrich Ries to Livingston Farrand, December 11, 1926. Original is in the Livingston Farrand Papers, 3/5/7, Box 20, File 20-51. A typed copy, with minor differences, is in the Heinrich Ries Papers, 14/15/691, File 1-23, RMC-KL, Cornell.

> this because it seems rather a crude production to come from a great University.
>
> "Professor Harris apparently wishes us to pay him personally $100 a month for the use of 'heat, light, library and museum facilities' of Cornell University. If the proper authorities of Cornell see fit to make a charge against all persons using these facilities of the University, we will pay our share; but we certainly do not intend to pay any sum whatever to Professor Harris personally for the use of any such facilities which do not belong to him, nor have we any intention of replying to his letter.
>
> "You are at liberty to show this letter to the Authorities, if you so desire.
>
> "Trusting that you will very soon be able to close this work and ship all of our materials, and with best wishes, I am
>
> "Very sincerely yours,
> "Signed Avery D. Andrews"[47]

Andrews also sent another telegram at about the same time as the above letter:

> "Miss Carlotta J. Maury
> "125 Eddy St. Ithaca, N.Y.
>
> "Letters referred to by Professor Harris practically identical first paragraph his letter December sixth of which you have copy stop he stated other companies left duplicates for museum and inasmuch as you had asked help from members of their surveys and made comparisons with their specimens without reciprocating it placed you in embarrassing position.
>
> "Andrew D. Andrews"

Ries added a typed note to the transcription of Maury's telegram, quoted above (based on information presumably provided to him by Maury) which he sent to President Farrand:

> "Miss Maury denies the general character of the accusation in last part of message. She claimed that she used only Weisbord and Olson [*sic*] collections for reference, and that these two men have used her books and specimens for reference.

On the same telegram copy in the Farrand Papers is a handwritten note by Ries not present on the copy in the Ries Papers:

> "Miss M. claims that in addition to consulting her own collections deposited here she has used only Weisbords [*sic*] and Olsons [*sic*], (This was a thesis), and that they have referred to her books and specimens, and she has given them help." [There was a pencil line drawn from this pencil note up to "their surveys" in the telegram transcription.] [Parenthetical in the original.][48]

The day this telegram was sent, Maury wrote to Ries again:

> "In connection with the statement that Professor Harris told the Company I represent over a year ago that certain conditions must be followed if their fossils were to be studied here, I would like to ask this question:—
>
> "Why was it right for him to study the *Rimella* zone box in my absence under circumstances that would be wrong for me? He reported on this box of fossils and was paid to do so.
>
> "If he retained duplicates where are they? And why were they not pointed out to me now when I was studying similar horizons and the person most entitled to have access to them for comparison?[49]
>
> "Perhaps I might add that the Caribbean Petroleum Company has international affiliations, with offices in New York, London and the Hague and is, I think, associated with the Royal Dutch Shell Company.
>
> "Very truly yours,
> Carlotta J. Maury [signed][50]

At this point it seems President Farrand asked Harris for an explanation. What Harris may or may not have said in that interview is known only from notes of Heinrich Ries. Ries was certainly not an unbiased observer, and he furthermore put these notes together several years after Harris had retired:

> ". . . the case of Dr. Maury (C.U.Ph.D.) who came to Cornell to check up some Tertiary fossils for the company she was working for. Harris demanded that she leave a completely labeled set with the University as he claimed others had done (a statement which is not true) and issued an ultimatum to her company that failing to do this he would demand payment for use of laboratory facilities, and that if the company did not meet this condition all their material would have to be removed in 48 hours or he would not be responsible for it. Miss Maury took the matter to the President, to whom she presented a copy of all correspondence (as well as one to myself). Harris when questioned by the President in my presence denied that he had

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[47] Letter from Avery D. Andrews to Carlotta J. Maury, December 10, 1926. Livingston Farrand Papers 3/5/7, Box 20, File 20-51; and a copy is in the Heinrich Ries Papers 14/15/691, File 1-23. RMC-KL, Cornell.

[48] Transcription of telegram from Avery D. Andrews to Carlotta Maury, December 13, 1926. Original transcription with pencil note added is in the Livingston Farrand Papers, 3/5/7, Box 20, File 20-51; the other copy without the additional pencil note is in the Heinrich Ries Papers 14/15/691, File 1-23. RMC-KL, Cornell.

[49] Here, and in the previous paragraph, Maury refers to the work Harris reported in his letter to Andrews on March 6, 1926 quoted above. In this letter there was no mention of any duplicate set of fossils being left at Cornell.

[50] Carlotta J. Maury to Heinrich Ries, December 13, 1926. Livingston Farrand Papers, 3/5/7, Box 20, File 20-51. RMC-KL, Cornell.

> ever made such a demand." [Parentheticals in the original.] [51]

In another set of notes, Ries remembered the events this way:

> "Miss Maury, a Cornell Ph.D., had a bunch of fossils to identify, which she had collected in connection with her field work for an oil company. She assumed that she might have the courtesies of the department and come here to identify them.
>
> "Shortly after she arrived Harris demanded that she leave a duplicate set here. She replied that she was not sure that she had a compete duplicate set, and furthermore would have to get permission of her company to do so.
>
> "Harris thereupon wrote a letter to her company repeating his demand. He said if it was not complied with by a certain date she would have to get out, and failing to do so he would not be responsible for what happened to her material. If she remained [at Cornell] a payment of $100 a month for the use of space, books, light, and collections. He did not say this was to be paid to the University. Miss Maury came to me with a copy of the entire correspondence (which I [Ries] still have). I took the matter to the Dean and he ruled that the President should handle it. I therefor [*sic*] told Miss M. to see Pres. Farrand, which she did, and also gave him a copy of all the letters. Farrand called Harris and myself into his office, and asked the former about it, and whether he had demanded any money of Miss M's company. Harris denied that he had, and Farrand did not contradict him, even though he knew Harris was not telling the truth. He [Farrand] later gave me the lame excuse that a professor could do about what he pleased in his quarters."[52]

Based upon the surviving letters, Ries seemed to have the facts correct, and one therefore may assume he is correct about what transpired at his meeting with Farrand and Harris.

What we know about what Harris put in writing comes from an unsigned carbon copy of a letter he wrote on "Paleontological Laboratory" letterhead to the Cornell President on December 16, five days after Ries filed his letter with President Farrand. Note how different Harris sounds in this letter to the University President after their meeting than he did in his earlier letters to the oil company personnel.

> "My dear Dr. Farrand:
>
> "If there really seem to be any dangers of 'foreign entanglements' at any time, I wish to suggest a way, a rather poor one however, but a certain one out.
>
> "I have had occasion to bring here a considerable number of books, equipments of various kinds, private collections &c, presuming, I think correctly, that the value to work here pays floor-space rental. I confess to having worked hard to have various outsiders, oil companies and others send me materials here to work up, feeling that the space they take up is very trivial in proportion to the help they give investigational studies, and best of all feeling that in practically every case such material will forever remain where last worked over.
>
> "Now, if in handling these materials I have overstepped my proer [*sic*] [proper] authority relative to University matters, I am anxious to apologize most humbly. But so far as partiality to outside individuals or corporations is concerned, anything but the most stupid type of self interest would check the slightest leanings.
>
> "If necessary to protect the University from criticism I can build some roomy apartment, off the University property and collect therein ally [*sic*] my own and these various collections that might possibly cause embarrassments and hence relieve all anxieties. But the expense involved would be considerable and the proximity to my work of my own books instruments, and the various collections while at the University seem to make the carrying out of this plan advisable only as a last resort.
>
> "Your most sincerely,
> Unsigned" [53]

A few days after Harris wrote this version of an apology letter to Farrand (there seems to be no evidence that he ever corresponded with Carlotta Maury again), Maury was again writing to President Farrand. Based on her letter, Harris, or Farrand repeating Harris, must have said something to her about how much work she did in the paleontology lab, and implied that she spent vast amounts of time there doing work for her company, for she seemed to be more than a little upset when she wrote this on December 18:

> "My dear President Farrand:
>
> "That you may know the slight amount of commercial work done by me in the paleontological laboratory of Cornell, I give the following list of *all* my commercial reports, the number of pages, and when recorded, the number of days:
>
> "1912 Large report published in Jour. Phila. Acad. Science, in their de luxe [*sic*], 100th birthday, volume. I wrote

---

[51] Un-signed and un-dated typed notes, believed to have been prepared by Heinrich Ries after or shortly before his retirement in 1939. Heinrich Ries Papers, 14/15/691, Box 3, File 3-2. RMC-KL, Cornell.

[52] Although these notes are un-signed notes, the use of phrases such as, ". . . after I became head, . . ." suggest they were written by Heinrich Ries. Based on a note attached to one set of these notes, at least one version was prepared in 1944 for Charles Nevin who was then head of the department. Among the Ries papers are at least three different versions of these notes, each evidently prepared at a different time. Heinrich Ries papers, 14/15/691, Box 3, File 3-2. RMC-KL, Cornell.

[53] Unsigned carbon copy of letter from Gilbert D. Harris to Livingston Farrand, President, Cornell University, December 16, 1926. HA-PRI, Ithaca, NY.

the report and paid Professor Harris to make the drawings. *All* the fossils which were described were brought back by me from South America and presented by the Company I represented to Cornell University. I was not paid to write this report and it was chiefly purely scientific.

"1915 About 1/2 dozen shells sent for identification.
Report maybe 2 pages. No copy retained.
"1922 May 29, A few shells.
Report 5 pages, including summary of past results.
"1924 December 20.
Report 8 pages.
"1925 June.
Report 4 1/2 pages.
"1926 June.
Report 11 1/2 pages. 14 days.
"1926 Dec.
Report 67 pages. 56 days.

"From this you may see how trivial the matter in its relation to the use of the Universities [*sic*] facilities really. [*sic*] has been. It is only this last report which has taken any time worth considering.

"In my letter of protest to Professor Ries, I have mentioned some of the non-commercial Memoirs and Monographs that I have written in the University's laboratories. All have been published and for the most part the collections and types are deposited in the Geological Museum. *All*, indeed, except the types belonging to the Brazilian Government which of course I had to return to Brazil, but whenever possible casts were made of these Brazilian types and are also deposited in the University's Geological Museum.

"My own feeling is this: I am deeply appreciative of the opportunities and privileges the University has afforded me to carry on my scientific work here, but I feel that I have given in return as far as I could. I have given collections; and I cannot but think that I have also brought scientific credit to the University.

"Very sincerely yours
Carlotta J. Maury [signed]

"P.S. I have not retained for myself a single specimen of all the various collections I have studied. Everything in my power to give, I gave to the University." [All emphases in the original.][54]

Two additional letters from this controversy bring it almost to a close. The first is from Maury to Farrand on December 28 and then his reply on the 29:

"My dear President Farrand:—

"As under the present circumstances it is not possible for me to complete here a paleontological report I am engaged on for the Brazilian Government, I would like to return soon to New York. But, having made a protest against unfair discrimination, I am ready to stand by, if it seems best to do so.

"Should you desire it, I would be glad to answer any question you might wish to ask me. And I enclose a memorandum of my principal monographs and memoirs and collections.

"Since there are in the Geological Department a great quantity of Venezuelan fossils belonging to the Standard [Oil Company] and affiliated Companies, it is difficult to explain the feverish desire manifested to obtain the few I held in trust, except in one way. Fossils from our highly productive wells would be illuminating for comparison with those from experimental drillings. They might be very helpful in the selection of land tobe [*sic*] leased for oil exploitation, in the same neighborhood.

"Whatever the motive, two facts remain:- the 48 hour ultimatum and the $100. a month, retroactive, private charge for use of University property.

"Most vital to me is the question whether I am to be debarred from all future privilege of studying in the Geological Department, and even of making comparisons with my own collections and types therein deposited.

"Very sincerely yours
Carlotta Maury [signed]"

The following memorandum accompanied the above letter.

"COLLECTIONS DEPOSITED IN THE GEOLOGICAL DEPARTMENT BY C. J. MAURY

"Freshwater Mollusca Central and Western New York. Cayuga Lake Basin Interglacial Mollusca.[55]
French and Belgian, Oligocene, Miocene and Pliocene Fossils.
Trinidad Eocene, and Venezuelan Cretaceous Fossils.
South African, Permian, *Glossopteris* flora.
Pondoland Cretaceous Fossils.
Port Elizabeth Tertiary Fossils.
Dominican Republic Miocene Fossils. A large and beautiful collection obtained by my own expedition.
Brazilian, artificial casts of types, returned to Rio de Janeiro.
(For further detail ask Professor Ries, Head of the Department)

PRINCIPAL MEMOIRS PUBLISHED BY C. J. MAURY

"*Paleontology of Trinidad Island. Chiefly Eocene.* Jour. Acad. Nat. Sci. Phila., 1912.
Santo Domingo Type Sections and Fossils. Bull. Amer. Paleont. Nos. 29 and 30, 1917.
Tertiary Fossils Porto Rico. Ann. New York Acad. Sci., Scientific Surver Porto Rico & Vol. 3 Pt. 1, 1920

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[54] Carlotta J. Maury to Livingston Farrand, December 18, 1926. Livingston Farrand Papers, 3/5/7, Box 20, File 20-51. RMC-KL, Cornell.

[55] This was the material from the Fernbank site on the western shore of the lake; see page 91.

> *Paleontology of Trinidad Island.Miocene.* Bull. Amer. Paleont. No. 42, 1925.
> *Tertiary and Cretaceous Fossils of Brazil.* (*Fosseis Teriarios do* Brasil &) Servico Geologico do Brasil, Monographia 4, 1924–25.
> Also an annotated Catalogue of the Mollusca of the Gulf of Mexico, and many minor articles on correlation, new species, new formations, &, in Science,; Amer. Jour. Sci.; Nautilus; Jour. Geology.
> (All these are deposited in the main University Library)." [All emphases in the original.][56]

Farrand's reply:

> "My dear Miss Maury:
>
> "I have your letter of yesterday and am not as yet in a position to make any positive statement. I am quietly gathering such information as I can as to the situation in general and have no doubt in due time a satisfactory mode of procedure in the laboratory will be worked out.
>
> "Under these circumstances, I see no reason why you should remain in Ithaca, for I think I have before me the essential facts from you which would be significant. As to the notice to remove your property, I believe that is not a question of immediate embarrassment, and as to a monthly charge for the use of University property, that if made at all, should be worked out on a basis applicable to all such users.
>
> "As to your own future relation to the Department, I can make no statement because that is obviously a personal situation. I know of no institutional reason why the same privileges should not be extended to you as to any other graduate or inquirer but I know of no way to remove mutual personal prejudices.
>
> "In conclusion I can only say that I trust a working basis will be arrived at after further consideration.
>
> "Sincerely yours,
> Livingston Farrand"[57]

Maury wrote one last letter to Farrand before departing from Ithaca:

> "Before leaving I would like to thank you for your letter, and to express appreciation of the desire of justice to all that you have shown. I am very glad you intend to place research work of industrial concerns at the University on an equitable basis. The University should have a proper return, but I think a Company should not be required to surrender materials potentially of great commercial value.
>
> "I am not an economic geologist. The Caribbean Company has thirty-eight oil geologists working in the Maracaibo field. They look on me as a scholar in pure paleontology and stratigraphy, and I am glad that they have this confidence in me. It's going to be hard to do the work away from the University, but I shall manage somehow.
>
> "I should be very sorry to have you think that I came knowing I was unwelcome. Had I known, I should not have come. Professor Harris was writing to my company without my knowledge. I returned, as I supposed, on the old friendly basis, I wrote, called on arriving, and asked at his office if I might have a table. He seemed very pleasant. Ten days before the eviction I was invited to dine at his house and all seemed kindly.
>
> "Yet I lost trust in his sincerity.
>
> "I am glad I have had no altercation with Professor Harris. When he saw me replacing books and trays, he said: [Harris] 'What, you aren't going are you?' [Maury] 'Of course. You do not suppose I would remain under these conditions!' [Harris] 'What is going on? I can't make it all out. I seem to be Nobody!' [Maury] 'A great deal of injustice is going on!' [Harris] 'Come and tell me about it.' [Maury] 'I do not wish to discuss it.' That was all.
>
> "I could not do otherwise than protect the materials and interests entrusted to me, and it seems right to me to have protested against injustice and attempted betrayal. I do not think it will be of any help to me, but it may prevent the reoccurrence of such an incident which is very unfortunate for those involved, and injurious to the reputation of the University. Conditions of commercial research in the Geological Department, being upon no established basis, now almost invite attempts to wrest valuable facts or materials from seemingly weaker rivals.
>
> "Yet I am more sorry than I can say that this has taken place. For Ithaca can never seem the same. I may never return, But my affection of the University, though saddened, remains otherwise unchanged."[58]

There was, however, a change in her affection for the University. Almost exactly a year later, December 16, 1927, Farrand received the following:

> "Dear President Farrand:
>
> "Lately a representative of the Cornell Alumni fund called. In reply to the request for money I said that I had just cancelled my long-standing legacy to the University. It was my purpose to double instead of cancelling this gift. But after waiting a year and receiving no reply to my protest regarding Professor Harris' very unscrupulous action I conclude that you condone it.
>
> "He is an old man,[59] and was my highly esteemed Professor and friend. I wished him no harm but thought he should be restrained from trampling on others.

---

[56] Letter and memorandum from Carlotta J. Maury to Livingston Farrand, President, Cornell University, December 28, 1926. Livingston Farrand Papers, 3/4/7, Box 20, File 20-51. A copy of the letter only is in the Heinrich Ries Papers, 14/15/691, File 1-23. RMC-KL, Cornell

[57] Livingston Farrand to Carlotta J. Maury, December 29, 1926. Livingston Farrand Papers, 3/4/7, Box 20, File 20-51; additional copy in the Heinrich Ries Papers, 14/15/691, File 1-23. RMC-KL, Cornell.

[58] Carlotta J. Maury to Livingston Farrand, January 4, 1927. Livingston Farrand Papers, 3/5/7, Box 20, File 20-51. RMC-KL, Cornell.

[59] Harris was 62 on October 2, 1926.

> "Although I told the Alumni representative to say nothing, perhaps after all you should know that this matter has cost the University a loss of twenty thousand dollars.
>
> "Sincerely yours,
> "Carlotta J. Maury [signed][60]

Farrand made an attempt to smooth the situation, but to no avail:

> "I have your letter of December 16th. Naturally I regret the situation which arose between Professor Harris and yourself a year ago and which I made every effort to clarify. As I told you at the time, there can be no institutional discrimination of any kind. Personal differences are unfortunately beyond administrative control and in the last analysis such differences seemed to form the crux of the situation at that time. I feel sure that Professor Harris is willing to conform to any general procedures which may be deemed equitable and wise. I am, of course, very sorry that you do not think you can work out with him the personal difficulty which arose between you but after repeated conferences I could not see a definite admissible step which would insure satisfaction to you and all concerned.
>
> "Sincerely yours"[61]

A few months later Farrand received what appears to the last word from Maury and he forwarded a copy to Ries:

> "Dear President Farrand:
>
> "The exposure of the corruption of the Sinclair-Standard methods may open your eyes to the truth of the situation in the paleontological department when I appealed in vain to you for fair play.
>
> "Mr Sinclair has been Professor Harris' hero for many years, unhappily replacing his admiration for the great men of the intellectual world. The Sinclair methods are the ideals of the paleontological department. The same deceit, and falseness, and fraud, is there, The 'oil smudge' is not only on the Republican party[62]. It is also Academic. Hence I sadly withdrew my allegiance from Cornell. Not from personal resentment.
>
> "Sincerely yours
> "Carlotta J. Maury"[63]

Farrand wrote to Ries:

> "Dear Professor Ries:
>
> "For your personal information and not for quotation in any way I enclose a copy of a letter just received from Dr. Maury. Is there anything at all in her charge? Don't take this up with Professor Harris, as I see no reason for re-opening that matter unless you think it advisable to do so.
>
> "Sincerely yours
> [Signed] Livingston Farrand[64]

The bequest had been withdrawn and now her "allegiance" was withdrawn as well. As a result of what she felt was a breach of professional ethics, she severed all ties with Cornell and with Harris. This situation apparently was not a total secret, for many years later in a set of typed notes Ries left the final word with regard to Carlotta Maury, Harris, and Cornell:

> "Miss Maury had in her will left an appreciable sum of money to Cornell for visiting lecturers in Geology. She canceled this bequest after the episode . . ."[65]

As mentioned earlier, by the time the Maury incident occurred, Harris had been working for several years as a consultant for various oil companies. Why he appears to have stepped beyond the bounds of propriety in this one case is not clear. Perhaps he was struck with a touch of avarice, for the oil companies apparently were paying him quite well and he saw an opportunity to raise his standing with his company, and concomitantly his salary. Perhaps the mixture of commercial and scientific activities that were being conducted in his laboratory at that time blurred the distinction between them in his mind. Was it a case of his temper taking control of his actions? If so, what made him angry? He left no record of his motivation, but Carlotta J. Maury left little doubt as to her feelings.

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[60] Carlotta J. Maury to Livingston Farrand, December 16, 1927. Livingston Farrand Papers, 3/5/7, Box 20, File 20-51. RMC-KL, Cornell.

[61] Carbon copy of a letter from Livingston Farrand to Carlotta J. Maury, December 22, 1927. Livingston Farrand Papers, 3/5/7, Box 20, File 20-51. RMC-KL, Cornell.

[62] Maury was probably referring to the scandals involving the leasing of Naval Oil Reserve land which rocked the political world in the 1920s. In 1922 President Harding's Secretary of the Interior, A. B. Fall, allowed Harry Sinclair to lease Tea Pot Dome (Wyoming) area and Edward Doheny (Pan-American Oil) to lease the Elk Hills (California) area without any competitive bidding in return for sizable "contributions." Although Fall was convicted of accepting a bribe and went to prison, both Sinclair and Doheny were acquitted. Sinclair did go to prison for contempt of court for refusing to answer questions and attempting to influence a jury (Allen, 1931). Details of the scandal would have been in the headlines in 1927–28.

[63] Carlotta J. Maury to Livingston Farrand, President, Cornell University, March 19, 1928. Original letter is in the Livingston Farrand Papers, 3/5/7, Box 20, File 20-51. A typed copy is in the Heinrich Ries Papers, 14/15/691. RMC-KL, Cornell.

[64] Livingston Farrand to Heinrich Ries, March 20, 1928. Heinrich Ries Papers, 14/15/691. RMC-KL, Cornell.

[65] Un-signed notes prepared by Heinrich Ries (uses the phrase, "..after I became head,. . ."). Based on a note attached to another draft in the file, these were prepared in 1944 for Charles Nevin who was then head of the department. In the Ries papers are several versions of these notes and each set differ but slightly in content. Heinrich Ries papers, 14/15/691, Box 3, File 3-2. RMC-KL, Cornell.

Based on the many letters and memos which Harris wrote to Ries and the other department heads, some of which have been quoted in a previous section, his difficulty with Maury seems to fit into a pattern of defensiveness and self-preservation. Some of this defensiveness is apparent in his letters to Maury. Harris does not refer to her as "Dr. Maury", the title she is given in some of the company correspondence and one that he had used for her in previous years, even though she received her Ph.D. under his direction. Perhaps this is related to the fact that he never received an earned doctorate himself, but was surrounded by colleagues who had, and he felt he had to "prove" himself in their eyes.

Certainly the most profound result to arise from the Maury episode seems to have been the Paleontological Research Institution, which Harris founded six years later. In the "apology" letter to the University President, Harris used the phrase, ". . . I can build some roomy apartment, off the University property . . ." This appears to be the first hint, at least in print, of what later developed into the Paleontological Research Institution, a private entity totally divorced from Cornell. In this way, he was able, at last, to gain control over his collections without the interference of University officials. Harris' bitterness towards Cornell only deepened as the years went by, and was perpetuated by his daughter long after his death. In her will, Rebecca Harris indicated that the $50,000 she left to PRI was to be donated to other charities if PRI ever "merges" with Cornell. This same feeling evidently translated into the feelings of Harris' successor and protegé, Katherine Palmer. Responding to questions from the National Science Foundation in December of 1961 as to current or future plans for any formal connection with Cornell, Palmer stated:

> "The Institution has no formal connection with Cornell University nor does it plan to establish any such connection in the foreseeable future. . . . The Institution cooperates with Cornell University as with other institutions; to maintain much the same relationship as exists between the Academy of Natural Sciences of Philadelphia and the University of Pennsylvania, American Philosophical Society or other similar institutions in the same area."[66]

The fact that this was written 29 years after the laying of the PRI corner stone and almost 10 years after Harris' death gives some indication of the depth of animosity that existed between Harris, his family, and those who followed him at PRI and Cornell. Not until the 1990s was PRI to have any significant connection with Cornell.

It also appears that the situation between Harris and Maury foreshadowed the current difficulties of deciding where university research ends and private company enterprise begins that exist within many universities today, especially with regard to molecular biology and pharmaceutical research. Now, however, faculty at many institutions are required to sign annual "Conflict of Interest" and "Disclosure Statement" forms declaring participation and/or ownership of any commercial venture even remotely related to their university teaching and research.[67] In this way the university seeks to protect itself, or at least gain prior knowledge of any potential difficulty, and situations like the Harris-Maury conflict should not arise.

There is an old saying that time heals most wounds, and to some extent, this seems to be applicable for Harris, and perhaps for Maury as well. On December 30, 1936, just over two years before Maury's death, in his address as retiring President of the Paleontological Society, Harris presented a history of Cenozoic paleontology (Harris, 1937b). In several places in his address, Harris acknowledged Maury's work and its importance to paleontology, *e.g.*:

> "C. A. White's mistakes in assigning all his fossil material on the northeast coast of Brazil to the Cretaceous were corrected in Maury's large memoir, published by the Brazilian government in 1924[68]." (Harris, 1937b, p. 456)

Perhaps this recognition by her former mentor and protagonist brought comfort to Maury before she died, and may have served to partially remove the deep bitterness resulting from their estrangement. Maury died at her home in Yonkers, New York, on January 3, 1938, after a year-long illness. She was only a few days shy of her 64th birthday.

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[66] "Information in reply to questions" sent to the National Science Foundation, December 6, 1961. PRI Archives, Ithaca, NY.

[67] This is the situation for the University of Pittsburgh.

[68] C. J. Maury (1924).

CHAPTER 8. CORNELL COLLEAGUES

Harris came into a difficult situation when he returned to Cornell in 1894. He and Adam C. Gill, the mineralogist, joined Ralph S. Tarr in a department that had been running with temporary appointments and graduate students for almost two years. Even with the additional faculty, Tarr was still required to teach economic geology, which was not to his wishes, and he continued to request another person. According to notes left by Heinrich Ries, later Head of the Department:

> "Pres. Schurman apparently agreed to this [hiring another geology faculty] reluctantly, but told him [Tarr] that if he appointed one the man need never expect to be promoted to a higher rank[1]. . . . Tarr was hoping to get a Harvard man as that was his Alma Mater. I heard of the position accidentally and applied. Gill subsequently told me that Tarr could not very well refuse me with my record and experience"[2]

Thus in 1898, the situation was further complicated by the arrival of Heinrich Ries[3], an economic geologist, who apparently was not Tarr's first choice. Eventually Ries split from Tarr and by 1902 each of the four was conducting business as a separate entity, and each communicated with the others formally on his own separate letterhead. In essence, there was no "Department of Geology" during this time. Even the University acknowledged that this arrangement had been in effect for many years in a committee report to the Board of Trustees in 1906:

> ". . . the Department was conducted by three independent heads; Professor Tarr having charge of dynamic geology and physical geography, Assistant Professor Gill having charge of mineralogy and petrography, and Assistant Professor Harris having charge of paleontology. Dr. Ries, who came as instructor to assist Professor Tarr, was in due time promoted to an assistant professorship with special charge of economic geology."[4]

For almost 10 years these four people, Harris (paleontology), Gill (mineralogy and petrography), Ries (Economic Geology), and Tarr (Dynamic Geology and Physical Geography) ran their respective sections, all in McGraw Hall, but acting as if they were virtually on separate planets. Although not many department records survive from this period, apparently each person was sending the university president a separate annual report each year.[5] This was the climate in which Harris interacted with his colleagues.

ADAM C. GILL

As might have been expected, Harris and Gill became close friends, and that friendship endured until Gill's death only five months after his retirement from Cornell in 1932. When the Harris' lived on Eddy Street in Ithaca, Gill, a bachelor at the time, was a frequent visitor. Harris prepared the professional memorial for Gill which appeared in the *Bulletin of the Geological Society of America* in 1933 and he recalled his friendship with Gill:

> "Early in 1894 Cornell University decided to broaden its work in earth sciences, and in the place of the former professorship in geology, have, at first, three assistant professorships, which were assigned as follows: Mineralogy, A. C. Gill; Physical Geography and Dynamic Geology, R. S. Tarr; Paleontology, G. D. Harris. It was then that the writer became acquainted with Professor Gill, and from that time until the day of his death our relations as colleagues and neighbors were most intimate and most cordial." (Harris, 1933, p. 326)

The Gill residence was on Wycoff Avenue, not far from where Harris built a home on Kelvin Place, and both shared a love of flowers which grew profusely in their back gardens. No doubt the two men walked together across the bridges over Fall Creek gorge countless times as they went to and from McGraw Hall. Perhaps because of this, there is, unfortunately, little record of their friendship aside from the Gill memorial.

RALPH STOCKMAN TARR

There is a similarly sparse record of the Harris-Tarr relationship, but apparently there was little love lost between them. As noted earlier, the University administration did not include Tarr in the decision to hire Gill and Harris, even though he had repeatedly requested additional assistance. When they were hired, Harris and Gill were afforded the same rank as Tarr, even though Tarr had been there for almost two years operating as a defacto department head. No doubt Tarr had some feeling of betrayal; this was probably not the kind of reward he expected after all his hard work to keep the Department functioning after the departure of H. S. Williams. His only advantage, and he may not have even known this, was that he was paid a higher salary than Gill or Harris, for they each received $1400 while he was paid $1700.[6] Add to this situation the fact that the University administration did not make an official designation for a department head when the faculty was enlarged. On the contrary, Harris came to Cornell armed with a letter from the President, quoted earlier, which stated that each person was to be independent of the other. All in all there was very little here to create a condition of cooperation and friendliness, at least between the two new faculty members and Tarr.

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[1] This turned out not to be true, for Ries was promoted to Assistant Professor in 1902 and Professor in 1906 (A. L. Anderson, 1952).

[2] Page 2 of typed, undated and unsigned notes. Because of the use of "I" and "me" in the narrative, these must have been written by Ries and based upon an attached note, they were prepared about 1944 for Charles Nevin, then head of the Department. Heinrich Ries Papers, 14/15/691, Box 3, File 3-2. RMC-KL, Cornell.

[3] Heinrich Ries appointed Instructor in Economic Geology for 1898–99, at a salary of $750; Cornell University Board of Trustees meeting minutes, April 12, 1898.

[4] Report on the state of the Geology Department and another related item, promotion of Heinrich Ries, presented to the Cornell University Board of Trustees by S. D. Halliday, R. H. Treman, and J. G. Schurman. Trustee meeting minutes, May 15, 1906.

[5] There are copies of Harris' reports for 1899–1900 and for 1900–1901; each printed with his own letterhead. HA-PRI, Ithaca, NY.

Ries described the situation between Harris and Tarr this way:

> "Tarr had not introduced me to Harris at all. I knew him by sight, so one day walking home to lunch I overtook him and introduced myself. Told him I was to teach Economic Geology. Said he was glad to hear it as the way it had been taught was execrable [*sic*]. (Tarr had been teaching it.) [Parenthetical in original.][7]

HEINRICH RIES

The only person to keep much a record of daily interaction with Harris during these years was Ries, who joined the faculty only four years after Harris and was head of the Department for almost 30 years. As the administrative officer, like Williams before him, it is expected that he would keep good records. The Departmental records of Williams and Ries, along with their personal notes, form the basis for much of what follows.

From the tone of the communications between Ries and Harris, it is clear that they simply did not get along well[8]. According to Harris' former student, Druid Wilson, when H. S. Williams retired in 1914, Harris expected to be named head of the department, but, instead, the position went to Ries. Also, Wilson, who knew both men, felt that Ries ". . . never gave Harris his due."[9] In defense of Ries, a department head often must hold a different view of things than the average professor, on matters such as operating costs and enrollments. From the existing records, it seems Harris' portion of the Department was very costly to run due to the small class sizes. As examples, the following are taken from Annual Reports Ries prepared for 1914–1915 and 1919–1920:[10]

1914–1915	Cost per Student-hour	
Class	1st Term	2nd Term
Elem & Econ. Geol	$ 2.77	$ 3.02
Physical Geography	5.40	6.08
Mineral—Petrology	10.50	8.70
Paleo & Strat. Geol	35.00	23.20
Dept. Average	4.30	5.00

1919–1920	Number of Students		Cost/Student-hour	
Class	1st Term	2nd Term	1st Term	2nd Term
Elem. Geology	287	301	$ 3.20	$ 3.25
Phys. Geography	155	73	4.30	8.75
Min—Petrology	73	80	12.00	13.00
Historic—Paleo	14	30	41.00	19.00
Economic Geol	151	152	4.10	4.50

A check of several other Annual Reports shows that, in general, Harris' classes had lower enrollments than any of his colleagues. As Ries had to answer to the University administration each year on these costs, no doubt this affected his personal relationship with Harris. Ries was not the only one to note the low enrollments in Harris' classes and the fact that for many years Harris was on campus only part of the regular academic year. As mentioned previously, in 1915 President Schurman inquired as to whether Harris was even needed full time or not[11].

Apparently Harris had little to do with the academic advising of undergraduates, a task that is vital to any department. Ries commented in a letter to Henry Leighton[12] that everyone in the Department had taken their share of undergraduate advising, almost everyone that is; "At present only Professor Harris, I believe, has never done so."[13] Certainly this would not have endeared Harris to his colleagues, all of whom were doing not only their share of the undergraduate advising, but his share as well.

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[6] Cornell University Trustees meeting minutes, January 9, 1894. RMC-KL, Cornell.

[7] "Notes on past conditions in Geology Department" Set of typed notes by Ries complied for Charles Nevin c. May 1944. Heinrich Ries Papers, 14/15/691, Box 3, File 3-2. RMC-KL, Cornell.

[8] This was confirmed by Dr. Lois (Schoonover) Kent. Personal communication, September 9, 1995.

[9] Personal communication, July 12, 1995.

[10] Annual Reports for 1914–1915, Box 2, File 2-1; 1919–1920, Box 1, File 1-85. Heinrich Ries Papers, 14/15/691, RMC-KL, Cornell.

[11] Jacob Schurman to Heinrich Ries, May 28, 1915. Heinrich Ries Papers, 14/15/691, Box 1, File 1-22. RMC-KL, Cornell.

[12] Henry Leighton (A.B.'06) worked for the Pennsylvania Geological Survey and was Professor of Geology at the University of Pittsburgh where John Wells was one of his students. It was Leighton who encouraged Wells to come to Cornell (Brice *et al.*, 1995).

Yet, regardless of the personal feelings, Ries defended Harris' portion of the Department and tried to maintain and increase financial support for paleontology. For example, in 1920–21, even though Harris had only 17 students in the first term, Ries filed this request with the President:

> "Professor Harris urges the need of a museum in which he can display his extensive collection of Tertiary fossils."

In another report by Ries:

> "The collections which he [Harris] has crowded on the top floor [of McGraw Hall], can probably not be duplicated anywhere in this country, and are of great value for students interested in his particular field."[14]

While Ries did show some sympathy for Harris' situation with regard to the need for collection space, he told Harris that McGraw Hall simply did not have any extra room. Ries, however, was not totally sympathetic to the request, and he continued:

> "Indeed I question whether the many type specimens of Tertiary fossils which he has, and which are of interest chiefly to a few graduates taking special work in that line, could not equally well be preserved for study in special cases of drawers."[15]

As is often the case, the professor can be the dreamer, but the department head must deal with realities:

> "Professor Harris wants to see vertebrate paleontology developed, but to do this would entail more expense as to equipment and space, . . . The number of students taking it would probably be very small, and it is my [Ries] personal opinion that is should hardly be attempted until we have plenty of money and space. He [Harris] likewise expresses a desire to have an instructor in Paleozoic Paleontology."[16]

In some of his private correspondence, Ries was less than complimentary even about Harris' research:

> ". . . Harris has I think the most cheerful habit of writing up every little bit of work he does as if no one else had ever been in the region, . . ."[17]

How much the conflict between Harris, the professor, and Ries, the department head, colored their personal relationship is very difficult to tell, but, based upon the surviving documents, it appears the personal side was as contentious as the professional. From what Ries wrote in a letter to the President in 1929, some jealousy existed over some of Harris' advantages. Note Ries' ability to both praise and damn in the same sentence:

> "I am returning herewith the letter which you received from Mr. K. E. Schmidt[18] regarding the establishment of a publication fund to assist Professor Harris with his publications. I may say that Professor Harris has for a number of years published at his initial expense the bulletins [*sic*] of American Paleontology and the Paleontographica [*sic*] Americana. The articles which have appeared in these are mostly papers on Paleontology by himself and his own students[19] and contain much valuable material. These have never been for free distribution but have been sold by him. It would of course be very nice if we can have a publication fund for the Department but I think that the rest of the Department might feel of course that if such a fund were established that the other branches should share in it. This other side of the matter is one which Mr. Schmidt knows probably nothing about as I find in looking up his record that he took 25 hours of work under Professor Harris and was not registered for an hour in any other branch of the Department. By publishing the paleontological papers himself Professor Harris is of course able to publish them in full with many illustrations while the rest of us have to be content with sending our papers and those of our students to the scientific journals in which they must necessarily appear in very much condensed form."[20]

Such was their relationship for over 50 years.

HENRY SHALER WILLIAMS

For Harris, and perhaps others, one of the saddest situations within the Department was the deterioration of the relationship between himself and H. S. Williams, his former professor and often strong supporter. Certainly they maintained a strong friendship in the early days, for very soon after receiving his appointment to

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[13] Heinrich Ries to Henry Leighton, October 21, 1926. Heinrich Ries Papers, 14/15/691, Box 2, File 2-3. RMC-KL, Cornell.

[14] *Annual Report for 1924–1925* by Heinrich Ries submitted to Dean R. M. Ogden, May 7, 1925, p. 3. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[15] *Annual Report for 1920–21*; N.D. Heinrich Ries Papers, 14/15/691, Box 1, File 1-85. RMC-KL, Cornell.

[16] *Annual Report for 1925–1926* by Heinrich Ries submitted to Dean R. M. Ogden, N.D.,p. 3. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[17] Heinrich Ries to H. P. Cushing, March 10, 1906. Heinrich Ries Papers, 14/15/691, Box 1, File 1-84. RMC-KL, Cornell.

[18] "Hans" Schmidt who was on the two *Ecphora* excursions in 1914 and 1915.

[19] About 70% of the papers in the first 100 issues of the *Bulletins* and all but one of the first 13 issues of *Palæontographica* were by Harris or his students.

[20] Heinrich Ries to Livingston Farrand, April 12, 1929. Heinrich Ries Papers, 14/15/691, Box 2, File 2-7. RMC-KL, Cornell.

Cornell in 1894, Harris wrote to Williams, who was then at Yale:

> "Having now received the appointment myself I shall spare no time and means to put invertebrate paleontology at Cornell on the best footing possible, i.e., within my power."[21]

It was not until Williams returned to Cornell that the two men became disenchanted with one another.

In 1904, H. S. Williams left Yale and returned to Cornell to assume the duties as head of the Geology Department, but with a concurrent half-time appointment with the U.S.G.S.[22] Part of Williams' duties for the University also included overseeing the museum which was housed in McGraw Hall.

During his stay at Yale Williams had apparently kept in touch with Harris, and shortly before his return to Cornell Williams wrote to him about a project:

> ". . . to map the Paleozoic rocks of the Ithaca Quadrangle this year. And if nothing arises to hinder [Edward M.] Kindle and I will be at work in the neighborhood during the summer."[23]

Williams asked Harris for recommendations for a field assistant who would have the highest potential. He also indicated that at least part of the collections resulting from this study would stay at Cornell. In this letter, however, Williams gave no hint that he was contemplating a return to Cornell, and indeed, there seems to have been little consultation by Williams or the University administration with any of the geology faculty about his return to the campus.

Of all the faculty, Harris appears, at first, to have been the most supportive of Williams. J. C. Branner wrote to Harris at the time Williams returned to Cornell:

> "In regard to Wms [*sic*] and Cornell: I find that Tarr has been trying to kick up a great dust about it, and that he has written to people outside of the University that he is so put out that he is disgusted almost or quite to the point of resignation. Of course such views should be expressed only to the President.
>
> "I am very glad that you told W. that you would frankly cooperate in building up a museum and in strengthening the graduate work. W. thinks highly of you, and of course nothing is to be gained by being cantankerous. A head to the department will greatly strengthen geology all round at Cornell. It certainly will look better to the world outside. You are not to infer from this that I have had any finger in the pie. I never knew anything about it until I heard a rumor of it when I was in N. C. but I ought to tell you frankly that it seems to me on the whole an excellent thing, though of course it is none of my business except in so far as it affects my friends, and affects the study of geology."[24]

Williams' return, however, only made a bad situation worse. While Ries' notes are admittedly not the most unbiased source, they are among the few surviving records of these times:

> "Williams was a mild mannered and kindly in his disposition, and if the others had been decent to him I feel sure he would have done a lot for them. Tarr was the most openly aggressive of the three, and did not hesitate to show his feelings."[25]

Things did seem to move smoothly for a while, at least on the surface. In his second Annual Report, Williams sounded optimistic:

> "There has been greater harmony and cooperation, together with the greatest freedom of the individual initiative consistent with good organization and best efficiency of the whole. . . .
>
> "The coordination and organization of the several individuals into a harmonious department, providing the best possible opportunity for students to perfect themselves in geological science as a whole, is the end toward which my chief energies are directed. My feeling is that this spirit is becoming more and more appreciated by my colleagues and is resulting in increasing regard for the general interests of the department."[26]

But the honeymoon did not last long, for Williams had a different philosophy for paleontology as a college subject than Harris did. This he outlined in a draft of his Annual Report for 1904–05:

> "My attitude toward the general policy of conducting the branch of work in Paleontology I will frankly state, 'Although it is my favorite branch of geological study my conviction is that it is of secondary importance as an elementary branch of university study; that it is a special field of investigation, of value to specialists as a preparation for professional work, but on account of the im-

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[21] Letter fragment, G. D. Harris to H. S. Williams, believed written before March 26, 1894. H. S. Williams Papers 14/15/728, Box 28. RMC-KL, Cornell.

[22] Williams was appointed Professor of Geology, Head of the Department and Director of the Museum, but only on half-time salary of $1750, plus $250 as department head and museum director, to become effective in 1904–05 academic year. Cornell University Board of Trustees meeting minutes, February 6, 1904. RMC-KL, Cornell.

[23] Henry S. Williams to G. D. Harris, May 30, 1903. HA-PRI, Ithaca, NY.

[24] J. C. Branner to G. D. Harris, March 24, 1904. HA-PRI, Ithaca, NY.

[25] Page 2 of a typed, undated and unsigned notes prepared by Ries about 1944 for Charles Nevin, then head of the department. Heinrich Ries Papers, 14/15/691, Box 3, File 3-2. RMC-KL, Cornell.

[26] Annual Report for 1905–1906 by H. S. Williams. H. S. Williams Papers, 14/15/728, Geological Correspondence Box. RMC-KL, Cornell.

> perfection of the materials presented for study it is inexpedient to allow students who are untrained in zoology and botany to specialize in the subject.' Further, I believe that to raise the study of paleontology from a mere examination of curiosities to the position of an exact science requires in the student a trained mind, in the first place, and, secondly, an immense amount of careful, systematic study. It is therefore my judgment that it is cruelty to encourage an ignorant freshman to play at study by allowing him to spend time at collecting and identifying fossils before he knows the elements of either zoology, botany, or geology, such as can be taught to beginners in the university. When, therefore, I discover that it is possible by the elective system for freshman to specialize in paleontology without either being trained to study and having no preparation in other sciences, I am disturbed and wish to disallow the practice."[27]

From this it is obvious that the teacher and his pupil had developed very different ideas since they had last shared a classroom, and the teacher was now once again in a position of control.

Harris *was* guilty of allowing his students to take few classes outside the area of paleontology. Ries commented on this in the quotation above concerning Karl Schmidt's letter and in a set of notes:

> "He [Harris] was interested in what he called bio-geology and saw no reason to make students in historic geology even take a course in elementary geology first."[28]

Certainly this was not the approach to paleontology recommended by Williams.

In yet another way teacher and pupil had moved apart. Williams did not consider the study of paleontology a suitable livelihood for most students:

> "He [Williams] considered the field of scientific paleontology to be limited in its possibilities for a livelihood, and consequently he never offered undue encouragement to prospective students to enter the work. To those who were bound to enter, however, he gave the best council and advice of which he was capable." (Weller, 1918, p. 700).

Meanwhile, Harris seemed to be doing just the opposite by having students work with him in the Louisiana Survey and with his extended boat excursions and field camp work. Harris, especially with his work with the Survey, demonstrated that the study of paleontology could provide a good living. The size of Harris' classes, however, did indicate that he was not bringing large numbers of students into paleontology.

In May of 1905, after a brief discussion that included a request for a pay raise for Ries, Williams wrote to President Schurman:

> "While speaking of this matter [pay raises], too, the case of Prof. Harris comes in. While I realize that Prof. Harris is a man of high merit as an investigator, as suggested in the conversation some time ago, there is the misfortune to him of having me as his colleague. I cannot recommend to the trustees to devote an excess of funds to the paleontological side of geology. Although I feel appreciative of Prof. Harris' ability I am not ready to urge increase of salary in that line, although I would like to see him appreciated and honored in such a way as the trustees can do. . . . He does not ask for a raise of salary at present as he has funds from the Louisiana Survey and from the U.S.G.S. sufficient to run his research work finely, and both of these outside [activities] helps detract from the amount of time he can give to the University."[29]

From this, it appears Williams was not happy with the half-time arrangement that Harris was working every year.

It was during this period that Harris came very close to leaving Cornell. In October of 1905, the beginning of Williams' second year back at Cornell, Harris began to make inquiries about a position at Louisiana State University (LSU), where most of the previous state geologists had been faculty members. In reply to his expression of interest, the LSU President responded:

> "I should like nothing better than to see a geological department established at this University, and to have you in charge of it. In fact, I have long had this step in mind, but it has never seemed practicable to carry it out. I am glad to find now that you are thinking along the same line, and that there is a possibility of our securing your services to build up such department here, and work in the state. . . . I should be glad for you to write me at once giving an outline of your plans for the organization of the geological work here, and state when you could begin the work as professor of geology at this University, whether it is your idea to remain here permanently or only temporarily, what salary you would wish, what sum would be needed to purchase the desired collections, and how you think your salary and your time should be divided between the University and the Experiment Stations [the State Bureau under which the Geological Survey operated]."[30]

Within days of receiving Boyd's letter, Harris must have written to J. C. Branner about his plans, for Branner offered this sage advice:

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[27] Draft of Annual Report for 1904–1905. H. S. Williams papers, 14/15/728. RMC-KL, Cornell.

[28] Typed notes prepared by Ries sometime between Harris' retirement in 1934 and the early 1940s. Heinrich Ries Papers, 1/4/15/691, Box 3, File 3-2, RMC-KL, Cornell.

[29] H. S. Williams to J. G. Schurman, May 12, 1905. H. S. Williams Papers, 14/15/728, Geological Correspondence Box. RMC-KL, Cornell.

[30] Thomas D. Boyd, President, Louisiana State University, to Gilbert D. Harris, October 2, 1905. HA-PRI, Ithaca, NY.

> "I can't tell you how sorry I am to get your letter of the 12th. There is no mistake about the fact that I have never in my life heard Williams say anything but good of you and your work. There is so much good scientific work to be done in this world that it seems to me a great pity that any one should spend his energies in personal controversies. The things you complain of are unworthy of your serious attention, and I cannot help thinking that you are being egged on by someone who is seeking to make a fool out of you by exaggerating the importance of a lot of very trivial matters.
>
> "None of the relations of life are just what we should like to have them; there is something to be put up with wherever we are and whoever our associates may be. Be patient, my dear fellow, and don't listen to the growler and the faultfinder. I hope to have better news from you next time."[31]

Part of Harris' disillusionment may have stemmed from the fact that by this time he had been at Cornell about 13 years, started his *Bulletins*, produced several Ph.D. students, amassed a large collection of fossils, and served with distinction as Geologist in Charge of the Louisiana Geological Survey, yet he had not been promoted to the rank of Professor (apparently there was no associate professor rank at that time). This, coupled with the return of Williams, certainly explains some of his frustrations. Harris was not alone, however, in trying to flee the department; it seems that all of them, except Gill, were threatening to resign in 1905 and 1906.

Williams wrote to all the geology faculty quoting from a letter from President Schurman:

> " 'I [the President] have received a letter from Professor Tarr in which he objects to the organization of the new course on practical geology and mineralogy which you have been contemplating for Engineers.
>
> " 'I have already notified you that Professor Tarr has informed me that he expects to leave Cornell University at the end of the next academic year. In view of that fact I suggest for your consideration the desirability of postponing for one year the establishment of the above mentioned course for Engineers.' "[32]

Harris carried his search for the position at LSU right to the point of being appointed:

> "I do not know whether the Secretary of the Board or I am most to blame for not sending you a formal notification of the action of our Board on the 10th ult., but to avoid mistakes, I will take the responsibility, and humbly beg your pardon for the delay. The Board elected you Professor of Geology, with the understanding that you will divide your time between the instruction of the University and the field work for the Experiment Stations, and that one half of your salary will be paid by the Experiment Stations and one half by the University. After conferring with Mr. Dodson as to the meaning of your letter October last, I have concluded to offer you a salary of $2500 per annum, your expenses, of course, to be paid while engaged in survey work for the Station. If I have misinterpreted your letter, please set me right at once. Please also let me know when you wish to begin the work in Louisiana, which term of our session you would prefer to spend in giving instruction at the University, and what courses of study you wish to offer. . . .
>
> "With kindest regards, and with much rejoicing over the prospect of having you with us permanently, . . ."[33]

Members of the department must have known Harris was actively seeking another position, for just as Harris was receiving the news that he had been appointed to the position at LSU, Williams was writing to Schurman expressing concern about Ries seeking another position, but showing little concern if Harris left:

> "The fact seems to be that he [Ries] is going right ahead seeking for another position, on the ground that he cannot get along with his present salary; believes he is worthy of a better salary; and receives from you no hope of a rise. . . .
>
> "My position has been very seriously attacked by men considering themselves to be friends of the University. I have endeavored to prevent harm to the university by giving no occasion for complaint on their part or those two members of the department who have openly sought to upset all the plans originating with me in the department. This policy has so far resulted in preventing these two men, messrs. Tarr and Harris from resigning. . . .
>
> "I think the Department would not be seriously weakened by the loss of the Assistant Professor of Paleontology, though he is a thoroughly able and energetic man in the line of paleontology he has cultivated. So that in considering the future of the department, I think it would not be inexpedient to make no reappointment at the termination of his term of office. . . . it will give less offense to Mr. Harris and his friends if the termination of his appointment be placed on the score of economy, rather than on any comparison with other needs of the department or with the merits of another member of the department. No doubt objections will be raised, whatever is done; but the criticism of the President and of his appointment of me over the department have come from both Mr. Harris and Mr. Tarr, and neither of them has as yet fully adapted the spirit of 'harmonious cooperation' which you indicated in your report as so essential to the . . . university. . . .
>
> "With the many matters in your mind you may not be

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[31] John C. Branner to G. D. Harris, October 18, 1905. HA-PRI, Ithaca, NY.

[32] Henry S. Williams to Professors Tarr, Harris, Gill, and Ries, March 23, 1905. HA-PRI, Ithaca, NY.

[33] Thomas D. Boyd, President, Louisiana State University, to G. D. Harris, June 2, 1906. HA-PRI, Ithaca, NY.

> able to realize the intensity of the strain at particular points of the institution, but I trust you will be able to give this matter sufficient thought to not allow the active departure of Mr. Ries from the University.
>
> "We must not lose our friends, while we are protecting ourselves from the attacks of our enemies."[34]

As it turned out none of them resigned. Ries received a raise and stayed:

> "After Pres. S. [Schurman] agreed to raise me, I withdrew my application out there [University of Michigan, at $2500/year].[35]

Instead of actually resigning, in 1906 Tarr took his portion of geology completely away from the Geology Department and created his own independent Department of Physical Geography[36], that was also housed in McGraw Hall. This arrangement remained until Tarr's death in 1912 when geology and geography were once again combined into a single department. Harris, too, apparently had second thoughts:

> "I [LSU President] very much doubt whether it would be well to make the temporary arrangement you suggest at this time. My idea when I asked the Board to elect you Professor of Geology here was to secure your whole time for the University and the Experiment Stations; but under all the circumstances I think you have acted wisely in not severing your connection with Cornell. This being the case, it now seems to me that it would be better for you to confine your work in Louisiana for the Stations just as you have been doing for the last number of years, and not to take up the work of teaching at the University until we can have a full personal conference about the courses of study to be offered."[37]

Even though he did not leave, it appears that Harris did not become a model member of the department, at least not according to his colleagues. Complaints continued to pour forth to Williams. Responding to Williams' request for him to teach introductory laboratory classes, Harris wrote:

> "Last spring I found the assistance in my branch of geology entirely inadequate for the large amount of work we were called upon to do. . . . I do not think it desirable or dignified for the professor who gives an elementary course to personally follow it up in the laboratory when cheaper help should do the work. I do not think such practice is customary."[38]

Still using letterhead paper with the heading "Cornell University" to one side and "Paleontology and Stratigraphic Geology, G. D. Harris" to the other, and no mention of the "Geology Department", Harris used quite a terse and sarcastic tone in some of his letters to Williams:

> "Memorandum relative to aims and needs of the Paleontological and Stratigraphical Division of the Geology Department of Cornell University, 1908.
>
> "The AIM of this division, section, or department at Cornell . . ."[Emphasis in the original.][39]

At one point Harris even addressed a letter as, "Prof. H. S. Williams, Dean, Geol. Dept., C. U."[40]

Despite this rancor, and perhaps unknown to Harris, Williams was requesting support from the University administration for his area of paleontology:

> "I think give more attention to development of Professor Harris's [*sic*] special line of work. One of the chief needs connected with such development is putting in order of the vast amount of collections pertaining to the Paleontology museum."[41]

In 1907, Harris had sought promotion to the rank of Professor by appeals directly to the University President, apparently not going through his department head. He received this reply:

> "The Trustees were not prepared to establish an additional full professorship in the geologicaldepartment [*sic*]. And the conferring of a title without the corresponding emolument was felt to be a dangerous precedent to establish.
>
> "All this simply means that the Trustees are unable to promote to higher positions many men who have rendered long, faithful, and meritorious service in their present position."[42]

Harris responded by saying that he had not asked for any additional salary, and further that he had agreed to never ask for a full year's pay. He went on:

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[34] H. S. Williams to J. G. Schurman, June 2, 1905. Attached note in Williams' hand says, "Personally discussed with him; letter not delivered." H. S. Williams papers, 14/15/728, Geological Correspondence Box. RMC-KL, Cornell.

[35] Heinrich Ries to H. S. Williams, July 22, 1906. Heinrich Ries Papers, 14/15/691, Box 1, File 1-75. RMC-KL, Cornell.

[36] Cornell University Board of Trustees meeting minutes, May 15, 1906. RMC-KL, Cornell.

[37] Thos. D. Boyd, President, Louisiana State University, to G. D. Harris, July 25, 1906. HA-PRI, Ithaca, NY.

[38] G. D. Harris to H. S. Williams, October 2, 1907. Heinrich Ries Papers, 14/15/691, Box 3, File 3-4. RMC-KL, Cornell.

[39] Memorandum, April 15, 1908. Heinrich Ries Papers, 14/15/691, Box 3, File 3-4. RMC-KL, Cornell.

[40] G. D. Harris to H. S. Williams, April 14, 1909. Heinrich Ries Papers, 14/15/691, Box 3, File 3-4. RMC-KL, Cornell.

[41] *Annual Report for 1908–1909* by H. S. Williams, April 28, 1909, p. 7. Heinrich Ries Papers, 14/15/691, Box 3, File 3-6. RMC-KL, Cornell.

[42] J. G. Schurman to G. D. Harris, May 31, 1907. Jacob Gould Schurman Papers, 3/4/6, Vol. 20, pg. 118. RMC-KL, Cornell.

> "Rumor has it that the Geological Department is already overmanned. This state of affairs has come about, if at all, by recent appointments over which the professor here concerned had no authority. He should not be made to suffer on account of the cost of new men."[43]

No doubt one of the "recent appointments" to which Harris referred was that of Williams three years earlier.

When it was to Harris' advantage, however, he was quite willing to cooperate with Williams. Just before he received his promotion and at about the time the funding for the Louisiana Survey had an uncertain future, Harris wrote to Williams from Louisiana:

> "Just now I am not bound by contract to anyone for the time mentioned. I thought perhaps as you have often expressed a desire for the arranging of General Geology under one man and as you have kindly suggested I would be the most fit for the work, would it not be well just now to suggest the matter to the President [of Cornell]. Naturally I should expect the beginning 'full' professor's salary, i.e., $2500 but since this would relieve Dr. Ries of so much work it would naturally give him the chance to dismiss one instructor. So the (1) cost would be no more to the University, (2) your idea would be finally carried out, (3) students would have more of two professors in place of an instructor. What objections can properly be made to these three points? Still, I am not thrusting myself anywhere. I simply suggest this now as it seems that I should know where I stand before agreeing to too much outside work."[44]

Williams must have interpreted this as a thinly veiled request for promotion, for he answered:

> "I have just received your letter this morning[45] and have taken it into the President and consulted him regarding the matter, and he says to tell you that there are several Departments in the University sadly needing more full professors, but that the Geological Department is not one of them, and he cannot recommend to the Trustees the appointment of another full professor in the Geological Department.
>
> "This, is seems to me, settles the question you raise. . . .
>
> "I still think it would be a desirable thing to have the General course in one man's hands, but the reply of the President seems to make this impossible, in the way at least, that you suggest it."[46]

Harris seemed to get the message loud and clear, but was, at the same time, saddened by the recommendations of the President:

> "Am very glad to hear the plain truth about the Geol. Dept. [*sic*] as seen by the President and shall naturally trim my sails accordingly. There are a whole lot of things I want to do here [Louisiana] in the next five years and according to present indications I shall have many more students down here at work than I ever had before. This I am willing to do and and [*sic*] teach 1/2 year at Cornell; but I am perfectly frank to say that in my judgment it would be no more than mere decency and of real advantage to all concerned to give me the rank as well as the pay (now given) of full professor while I am at the University. It would cost nothing (even in dignity) it seems to me to make the change. I wish there were some way of making the President give his reasons against the change. I have already agreed to swear off from all claims of permanency and to never ask increase in pay. There is some . . . [one behind this] . . . and the President isn't going to point him out."[47]

There is no way of knowing who Harris thought was standing in the way of his promotion, but given the past differences he had with Williams, it is not unreasonable to assume he felt Williams was that person.

Later, despite all their differences, Williams eventually was able to obtain Harris' promotion. Note Williams' use of the word "again" in the letter below. This evidently was not the first time he had attempted to gain Harris' promotion:

> "Recognizing the fact that peace of mind and good feeling are essential to the most effective work, I want to call attention to the unhappiness of my colleague Assistant Professor Harris because he is still rated an Assistant Professor. I believe his ability is widely recognized through out the country as a first class Geologist and Paleontologist and I believe he should be recognized as a full Professor. He devotes half of the year most earnestly and effectively to the work of the Geological department, and is a devoted loyal Cornellian. I therefore, again, (and urgently) recommend that some way may be found to give him the title of Professor of Paleontology."[48]

Harris was promoted to "Professor of Paleontology and Stratigraphic Geology (part time)" by action of the Board of Trustees on May 19, 1909.[49]

In this same letter Williams made another attempt to bring peace and harmony to the department. At this point, apparently in desperation, Williams did relinquish his control of the department with a suggestion to the President and Trustees that the department be run by a committee, "The Geology Conference."[50] This action tends to support Ries' assessment of Williams' personality mentioned earlier, and it shows that Williams was trying to get, and keep, the department running smoothly. The committee approach, however, did little to ease the situation.

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[43] Two page, printed (probably by Harris) legal-looking extract "Subject—Change of title with no change in compensation *Case of Assistant Professor Harris asking to have the word 'Assistant' dropped from his title.*" N.D. HA-PRI, Ithaca, NY.

[44] G. D. Harris to H. S. williams, November 2, 1908. Heinrich Ries Papers, 14/15/691, Box 3, File 3-6. RMC-KL, Cornell.

[45] Note the two day mail service between Jennings, Louisiana and Ithaca, New York in 1908.

[46] H. S. Williams to G. D. Harris, November 5, 1908. Heinrich Ries Papers, 14/15/691, Box 3, File 3-6. RMC-KL, Cornell.

[47] G. D. Harris to H. S. Williams, November 7, 1908. Heinrich Ries Papers, 14/15/691, Box 3, File 3-6. RMC-KL, Cornell.

[48] H. S. Williams to J. G. Schurman, May 19, 1909. Heinrich Ries Papers, 14/15/691, Box 3, File 3-4. RMC-KL, Cornell.

[49] Cornell University Trustee Meeting Minutes for May 18–19, 1909. RMC-KL, Cornell.

This constant bickering between the Williams and Harris continued at various levels until Williams' final retirement in 1912, and even beyond. Williams had been granted some research space on the top floor of McGraw Hall, and Harris had eyes for some of the storage drawers located there; Ries had other ideas:

> "As for your room on the top floor; no one will be allowed in there. That is for *your private use*, as long as you want it. . . .
>
> "Harris as you know has the southwest room on the top floor. He wants to put a lot of drawers in racks along the east side of that room. It was for this purpose he suggested the possibility of getting the vacant racks in your room. . . .
>
> "I [Ries] told him [Harris] this morning that actually and proportionately he had more floor space now that any other branch of the department." [Emphasis in the original][51]

So, the relationship between Harris and Williams which began with warmth and mutual respect, ended with bitterness and distrust. The last few years of Williams' life were spent in Cuba, and he died in Havana in 1918 (Weller, 1918).

Even after Williams' death, however, Harris was not above appealing to the memory of his colleague to advance his own cause:

> ". . . there should be at once a move made to raise funds for an International Devonian Museum here, in the center of the best Devonian section in the World [*sic*]. This should be a shrine, as it were, to the memory of Professor H. S. Williams and should be financed by the Williams family. They have given little so far but I believe might take hold of such a proportion if properly approached. This naturally should be quite separate from the general paleontological museum."[52]

Many years later, Harris still did not acknowledge that his actions had any thing to do with the turmoil that existed during Williams' tenure as head of the department:

> "Professor H. S. Williams could have done wonders here [at Cornell] if he had managed a little differently financially and had gotten material to work on for Cornell, and not for the U. S. Geol. Survey."[53]

In defense of Harris, however, it can be said that while Williams came with high hopes for the department, his focus may have been a bit narrow. In his diary, written the first week of April 1904, Williams said:

> "I believe it may be truthfully said, that with the return of the Devonian laboratory of the U. S. Geological Survey to Cornell no other university will possess the facilities so well adapted for advanced research in regard to problems of evolution of Paleozoic life and their relation to historical geology and to the principles of correlation in the Paleozoic rocks as Cornell."[54]

Williams also wrote about the need for vertebrate paleontology, more exhibits, and certainly emphasized his own area of Paleozoic paleontology, but he said very little about Tertiary paleontology. Perhaps Williams was so focused on the old rocks he had little time for the younger ones and the people who did.

O. D. von ENGELN

Harris and Oskar D. von Engeln may have had an amiable relationship. Von Engeln came to Cornell as a student in 1904 and was associated with the Department until his death in 1965; more than 60 years. Exactly how amiable the friendship was between Harris and von Engeln is difficult to say because "Von", as he was known, was a student and protegé of R. S. Tarr, and from what can be determined, Tarr and Harris did not get along very well. But according to Ries, Harris and von Engeln must have been friends:

> "There did not seem to be any use objecting [to appointing O. D. von Engeln an assistant professor] and I felt thatif [*sic*] I said anything against [the appointment] Harris would tattle it to O. D. [von Engeln]. . . ."[55]

Von Engeln had a home on Kelvin Place not far from Harris and Gill, and it would have been normal for him to join the others in walking from home to McGraw Hall. Perhaps photography provided von Engeln and Harris a mutual interest. Von Engeln was the photographer on several expeditions to Alaska with Tarr, and he took what may be one of the most famous photographs of the Cornell campus in the early Twentieth Century. Von Engeln sold copies of it under various names, "Rainy Day on Campus" and "In College Precincts" (Brice, 1989), and it appeared in magazines of the day (Von Engeln, 1907).[56] The photograph was the product of a serendipitous event, for he was just testing a camera in the rain before embarking on the 1906 expedition to Alaska[57]. He set up the camera outside McGraw Hall, and tripped the shutter just as two students walked by. He framed the pair as they walked in the rain under the stately elm trees that used to grace the Arts Quadrangle of Cornell.

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[50] The suggestion was approved by the Trustees; Cornell University Board of Trustees meeting minutes, May 19, 1909. For details, see the chapter "Period of Confusion" in Brice ,1989, p. 74–83.

[51] Heinrich Ries to H. S. Williams, December 12, 1914. Heinrich Ries Papers, 14/15/691, Box 1, File 1-76. RMC-KL, Cornell.

[52] G. D. Harris, Annual Report for Heinrich Ries, May 8, 1928. Heinrich Ries Papers, 14/15/691, Box 2, File 2-7. RMC-KL, Cornell.

[53] *Annual Report* by G. D. Harris to Heinrich Ries, May 8, 1928, p. 2. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[54] H. S. Williams' Diary and Course Book, p. 119. Heinrich Ries Papers, 14/15/691, Box 3, File 3-9. RMC-KL, Cornell.

[55] Typed note by Ries complied c. 1944 for Charles Nevin. Heinrich Ries Papers, 14/15/691, Box 3, File 3-2. RMC-KL, Cornell.

Both von Engeln and Harris believed in the power of illustrations, and in their teaching they used lantern slides, large 3″ × 4″ glass black and white positives which could be projected on to a screen (today replaced by the 35 mm color transparency). In their publications von Engeln used photographs of landscapes while Harris used photographs of fossils and outcrops. Perhaps this common interest overcame what differences might have existed with von Engeln's association with Tarr.

Von Engeln was one of the three people who prepared Harris' faculty memorial which stated, "Professor Harris did not cultivate wide social contacts." (Herrick *et al.*, 1953, p. 16A). Von Engeln evidently had fond memories of Harris, for he dedicated is 1961 book to "The Faculty Stalwarts: Tarr, Gill, Harris of the Good Old Days in the Geology Department of Cornell University" (von Engeln, 1961). Apparently, however, there was little social contact between the two, for in his *Reminiscences*,[58] a 214 page handwritten autobiography prepared when he was 83, von Engeln made almost no mention of Harris. The only reference to Harris appears in the section in which von Engeln was describing the situation when H. S. Williams returned to the department in 1904:

> "The return of Williams and elevation to head was most distasteful to all three, Tarr, Gill and Harris and later, 1914, [the] succession of Ries Williams's [*sic*] protege, was greatly resented by the survivors, Gill and Harris."[59]

Thus, even though they were colleagues in the same building for almost 50 years, that is all von Engeln had to say about Harris in the telling of his own life's story.

RETIREMENT

Harris retired from Cornell in 1934, after 40 years of association (Plate 13). To mark the occasion, the University Faculty and the Cornell Board of Trustees unanimously adopted the following resolution:

> "Gilbert Dennison Harris born at Jamestown, New York, October 2, 1864; graduated by Cornell University in June, 1886, with the degree of Ph.B.; assistant and associate professor[60] of Paleontology and Stratigraphic Geology at Cornell from 1894 to 1909; Professor of the same since 1909; retired as of October 2, 1934 [his 70th birthday].
>
> "Because of various preempting factors occurring in more general fields of geology, Professor Harris soon became interested in the belt of Tertiary rocks which occur all over that vast territory of the United States from Maryland to Texas. Thus, he early began to make intensive studies of the stratigraphy of the Tertiary and of the fossils lying at hand everywhere over that wide area. It was not long before he became known throughout the world as an authority on Tertiary Stratigraphy.
>
> "During the six years immediately following graduation, Professor Harris became successively a member of the Arkansas Geological Survey, of the United States Geological Survey, and of the Texas Geological Survey. Subsequently he was State Geologist[61] of Louisiana for ten years and for a time special lecturer in Paleontology and Stratigraphy at the University of Texas. Professor Harris and his students have described hundreds of species of fossils from the Tertiary of the southern United States, Central America, South America and Africa, and their studies have extended to southern England and northern France. As a result of these studies, hundreds of type specimens of fossils have accumulated which constitute a priceless and absolutely essential collection to all students of the Tertiary in the countries indicated.
>
> "He was one of the first to recognize the relationship existing between salt domes and commercial oil and gas fields and years ago made a special study of salt domes with the publication of several pioneer papers on the subject.
>
> "Professor Harris early recognized the necessity of a medium for the publication of the original descriptions of new forms and of the papers on stratigraphy by himself and students. He, therefore, established the Bulletins of American Paleontology for the more general papers and the Palaeontographica Americana for the monographic papers. These publications he has always printed on his own private press, has, indeed, set the type himself for many of them and formerly made the plates. This work, with the Bulletin now in its 22nd volume, and with many monographs of the Palaeontographica, has been truly prodi-

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[56] The photograph was on the cover of *The Interior*, Educational Number, v. 38, no. 1940, August 1, 1907.

[57] A photograph of von Engeln developing film in a glacial meltwater stream during the 1906 expedition was reprinted in *National Geographic*, v. 188, no. 2 (August), 1995, p. 130

[58] O. D. von Engeln Papers, 14/15/856, Box 1, File 1-45. RMC-KL, Cornell.

[59] O. D. von Engeln Papers, 14/15/856, Box 1, File 1-45, p. 136. RMC-KL, Cornell.

[60] This rank did not exist during that time period. There were two grades of assistant professor. Trustee minutes for May 18–19, 1909, state, "Assistant Professor G. D. Harris to be Professor of Paleontology and Stratagraphic [*sic*] Geology . . ."

[61] His official title was, "Geologist in Charge" (Pope, 1988).

> gious-difficult to understand how it has been possible for one man to do. Moreover, the plates of two publications have scarcely been equalled in quality and finish and are still considered the best in their field today.
>
> "In addition to his extensive labors here at Cornell and in Louisiana, he has been consulting geologist for the Trinidad Petroleum Development Company and Paleontologist to Standard Oil Company of Venezuela.
>
> "As a teacher, his courses have been rather specialized and technical for the undergraduate but no man anywhere has received greater admiration and unbounded loyalty from graduate students than has Professor Harris. His quiet, restrained, modest character, combined with his devotions to the interest of his students and to the ultimate fruition of their labor has inspired many of these men and women with a fervent zeal and lasting allegiance to him and to Cornell.
>
> "Professor Harris is now preparing with the greatest enthusiasm to carry on his work in paleontology and stratigraphy of the Tertiary. He has great collections available and properly housed. Several of his former graduate students are now at work with him and our best wishes are extended to him for many productive years of labor in his chosen field"[62]

This and a small reception at the Department organized by a Mr. J. M. Parker, 3rd[63] and given by the Department, Chi Upsilon, and Sigma Gamma Epsilon,[64] ended his formal connection with Cornell.

Harris did, however, maintain an office in McGraw hall for several years after retirement. A former student, who was at Cornell shortly after Harris retired, remembers seeing him carrying fossils and manuscripts back and forth everyday from home to the office. He was so afraid of a fire in McGraw Hall, that he would not leave important materials in his office.[65] Ries described the situation:

> "Professor Harris works over here [McGraw Hall] spasmodically. He retains his desk in the same place it has been for years, and all of his Tertiary (except for what he has taken away) is in the next room, . . . , Harris suffers no retrenchment."[66]

Harris was certainly leaving his mark on McGraw Hall, for about the time he was retiring, Ries informed him that the University officials were concerned about the load on the floors in McGraw Hall from the many drawers of rocks and fossils that were stored there.[67]

But two years earlier, Harris had already begun a project that was to remove him permanently from McGraw Hall and Cornell, and which would occupy him for the rest of his life, the Paleontological Research Institution.

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[62] Adopted at the Trustees meeting of February 2, 1935. Resolution was drafted by A. H. Wright, C. M. Nevin and Glenn W. Herrick. These names are on a copy of the resolution at HA-PRI, Ithaca, NY.

[63] The name is mentioned in a letter from George M. Martin to Heinrich Ries, October 6, 1934. Heinrich Ries Papers, 14/15/691, Box 1, File 1-25. RMC-KL, Cornell.

[64] This information comes from a small article, believed to be from the *Ithaca Journal*, but exact date and page are unknown, most probably in October, 1934. HA-PRI, Ithaca, NY.

[65] Lois Schoonover Kent, personal communication, September 8, 1995.

[66] Heinrich Ries to John L. Rich, April 8, 1935. Heinrich Ries Papers, 14/15/691, Box 1, File 1-24. RMC-KL, Cornell.

[67] Heinrich Ries to Gilbert D. Harris, October 15, 1934. Heinrich Ries Papers, 14/15/691, Box 1, File 1-23. RMC-KL, Cornell.

CHAPTER 9. "SOME ROOMY APARTMENT": POST-RETIREMENT AND THE PALEONTOLOGICAL RESEARCH INSTITUTION

The years after his retirement in 1934 were, as was normal for Harris, busy ones, as he continued to edit and publish his two journals. In fact one of the last known photographs of Harris, taken three years before his death, shows him bending over his printing press as he printed yet another issue (Plate 14). He continued to personally run the press until 1949, his 85th year, and number 134 of the *Bulletins*, when failing eyesight[1] forced him to relinquish his position as editor, printer, and publisher (Palmer 1953a, b). There was a delightful newspaper article by Carl B. Kaufmann entitled: "Professor Still Active At 85 In Field of Paleontology"[2] which was accompanied by the photograph of Harris and his printing press. In the article Kaufmann noted that although he was practically unknown "outside of science", Harris did not mind; it ". . . is of little concern . . ." to him. Further, Kaufmann brought out the fact that while the *Journal of Paleontology* was a ". . . subsidized, staff-prepared affair.", Harris' journal was a one-person operation. At that time, only three years before his death, he was running 600 copies of the *Bulletins* in a single press run.

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[1] "My eyes are rather going back on me but maybe they have a right to after 86 years." Original letter, Gilbert D. Harris to H. C. Kugler, June 15, 1951. HA-PRI, Ithaca, NY.

[2] *The Ithaca Journal*, Thursday Evening, November 3, 1949, p. 5.

In retirement there was time for more travel. For example, in November, 1935, with each person paying his or her own expenses and Harris providing the automobile transportation, Rousseau Flower, Katherine Palmer, and Harris took a trip through Tennessee, Louisiana, Mississippi, Alabama, and Florida visiting and collecting in over 31 localities (Palmer, 1982). Two years later, in 1937, Ralph Liddle (A.B.'18) and his wife Pearle took Harris by automobile across the U. S. to California and the West Coast on a collecting trip. The next year, with assistance from a grant from the Geological Society of America, Harris, Katherine Palmer, and her husband, E. L. Palmer, made an extended trip to examine the Gulf Coast from Florida to Arkansas. One highlight of this venture came with the discovery of an unexpected fossil. While examining some strata near Forrest City, Arkansas, Harris discovered a vertebra of a zeuglodont, *Basilosaurus cetoides* (Owen), which was part of the first known[3] remains of this extinct whale found that far north (30 degrees) (Palmer, 1939). In 1902, based on other fossils, Harris had assigned the Jackson units to the Eocene and *B. cetoides* confirmed the presence of these Jackson beds in the Forrest City area.

He finally found the time to complete the opus on the turrid gastropod illustrations, a project he had started almost a half century earlier (Harris, 1937a). He kept busy with other research publications (Harris, 1934b, 1940, 1951) and professional activities, serving as President of the Paleontological Society in 1936, and Vice President of the Geological Society of America in 1937. His address as the retiring President of the Paleontological Society provided him with an opportunity to outline the history of Cenozoic marine paleontology, to which he and his students had added many chapters (Harris, 1937b). In 1939, Harris was elected a "Correspondent of the Academy" by the members of The Academy of Natural Sciences of Philadelphia, one of the oldest scientific organizations in the United States, founded in 1812[4].

But on a personal side, these were lonely years for him. Two years before he retired, Harris suffered two irreplaceable losses. First Clara, his wife of almost 42 years and the mother of their only child, became ill in late 1931:

> "I have [*sic*] sorry to learn that Mrs. Harris is not well. [*sic*] but I trust it is only temporary and it will not be long before she will be well once again."[5]

But apparently the illness persisted well into March of 1932 and beyond: "Hope Mrs. Harris is improving."[6]; and:

> "I was sorry to learn of Mrs [*sic*] Harris [*sic*] bad health. No doubt the unseasonable weather we have been having lately is largely responsible. The winter cannot last much longer and with the return of sure-enough Spring, Mrs. Harris's [*sic*] health will surely also return"[7]

Her health did not return and Clara died on August 12, 1932.[8] These life-long companions were not destined to go into their twilight years together.

Then his friend, colleague, and neighbor, Adam C. Gill, died in November of that same year shortly after his retirement from Cornell (Harris, 1933). Despite all his activity and the best efforts of his friends and his daughter Rebecca, the loneliness and the void in his life caused by these losses must have remained:

> "But you can imagine the sadness of opening Christmas good wishes with the light of our home gone out, But I suppose such things must just be. . . .
>
> "After a hard week of winter we are enjoying beautiful spring-time weather during holidays. . . . Nature is O.K. if man is vile!" [Emphasis in the original.][9]

It appears that his sister-in-law, Bertha Stoneman, came back to New York after Clara's death:

> "We are expecting Mrs [*sic*] H.'s sister from S. Africa in Feb. but fear she will be so wedded to the dark continent that she will be returning after a few months."[10]

But apparently she did stay, at least for a while, for Palmer (1982) lists her among the Charter Members of PRI; however, she was not present at the laying of the corner stone. She was in Chatautqua County at that time, "R.D. 3, Jamestown, New York", and was one of the three people, along with Harris and Rebecca, who signed the $1,000 "Surety Bond" for PRI on October 17, 1934[11]. Bertha Stoneman's name appears also on an undated, but obviously early, list[12] of PRI members with her address listed as "PRI." She did eventually return to South Africa[13], for PRI records show that she resigned her membership "April 31 [*sic*], 1943" (obviously a mis-typed date), and her address then was Huguenot University College, Wellington, South Africa.[14]

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[3] As of 1953, it was still the only such remains ever found that far north (Palmer, 1953a).

[4] James A. G. Rehn, Corresponding Secretary, to Gilbert D. Harris, September 26, 1939. HA-PRI, Ithaca, NY.

[5] Axel Olsson to Gilbert D. Harris, December 28, 1931. HA-PRI, Ithaca, NY. The nature of her illness is not known.

[6] Cecil Card to Gilbert D. Harris, March 15, 1932. HA-PRI, Ithaca, NY.

[7] Axel Olsson to Gilbert D. Harris, March 30, 1932. HA-PRI, Ithaca, NY.

[8] *Ithaca Journal-News*, Monday, August 15, 1932, p. 3.

[9] Original letter, Gilbert D. Harris to "Hodsoni" [Floyd and Helen Hodson], December 29, 1932. HA-PRI, Ithaca, NY.

[10] Original letter, Gilbert D. Harris to "Hodsoni" [Floyd and Helen Hodson], December 29, 1932. HA-PRI, Ithaca, NY.

[11] HA-PRI, Ithaca, NY.

As he approached his retirement in 1934, the largest part of Harris' energies were directed toward his newly formed Paleontological Research Institution. PRI, as it was and is known, was founded in 1932 and chartered by the State of New York as an educational institution October 12, 1933[15]. It is always difficult to determine an individual's motivation when there are few records of their thoughts, but there seem to be at least three, and possibly four, major influences which caused Harris to create PRI. Alone probably none of these would have been sufficient, but in concert they were a powerful force.

The first of these was Harris' fear of fire.[16] McGraw Hall was filled with wooden floors, ceilings, stairways, tables, chairs, etc., all of which were very flammable. One of Harris's great concerns was that his collections could be lost if McGraw Hall ever caught fire. The old wooden inner structure and all the wooden drawers were hardly fireproof. His fears were not unfounded, for fires in university buildings had certainly occurred:

> "Although most of the records relating to your work at McGill University were burned in the fire which destroyed the Engineering building . . ."[17]

Even at Cornell only a few months before Harris retired a fraternity house was destroyed by fire.[18]

As the years went by, he appears to have become more and more obsessed with this fear. As early as 1915 in a letter to Veatch after receiving his $1,000 donation, Harris said:

> "My feeling is that in the end the large collection of type and illustrated specimens to be hereafter collected as well as those that I have been bringing here for the past 20 years should be left finally at Cornell, provided the University see to it that a fire-proof quarter is arranged for their reception. What funds we can accumulate should be left as an assistantship or scholarship with special reference to the care and upkeeping of these collections."[19]

At this time Harris makes no mention of creating a private institution.

Again in 1919, in his budget request to Ries, Harris said:

> ". . . and I hope every effort is being made to either have a small fire proof addition made to this building or to 'fireproof' the entire structure. Insurance at present seems to be rather high for things in this building [McGraw Hall]."[20]

Ries certainly shared Harris' concern about fire, for in his report for 1922–23, Ries complained about the fire danger in McGraw Hall and mentions the irreplaceable items that would be lost if a fire should occur:

> "Professor Harris has added greatly to the collections of Tertiary fossils, which are a special feature of the research carried on in his branch of the department."[21]

In a letter to Ries, May 2, 1924, Harris carried the fire danger complaints further, this time trying the comparison approach:

> "A student from a neighboring, impovershed [*sic*] institution [unnamed] remarked the other day: What lots of fine things you have here, but Oh [*sic*] if you only had our building! A visiting professor from the West remarked: I admire the class of work you are turning out, but I dont [*sic*] like the quarters you work in. We shall hear these remarks again and again. . . .What is to be done? Personally I can get along without electric fans or even great and marble-floored apartments, even trudge sometimes dozens of times a day up the equivalent of 5 flights of stairs. But what stings me to the quick is the danger I am running here every day of the destruction by fire of almost my life's work.
>
> "I had supposed that mere buildings were comparatively easy to find donors for[22], but we seem to be in the plight

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[12] The list is typed on the same paper and accompanies a dues list which is dated 1936. HA-PRI, Ithaca, NY.

[13] She had a "Power of Attorney" recorded for her in Jamestown on July 9, 1936. Walter L. Miller, Attorney-at-Law, to Gilbert D. Harris, March 3, 1937. HA-PRI, Ithaca, NY.

[14] Membership 1950; Resignations. HA-PRI, Ithaca, NY.

[15] The Absolute Charter was granted on November 20, 1936 (Palmer, 1982).

[16] An Ithaca newspaper column by John Chiment published at the time of the 61st anniversary of PRI made particular note of this fear in the title, "The man who collected fossils and hated fires." *The Ithaca Journal* August 14, 1993. Chiment, a former employee of PRI, was Dean of Freshman at Cornell University in 1995.

[17] Frank Adams to L. C. Graton, March 15, 1913. Heinrich Ries Papers, 14/15/691, Box 1, File 1-17. RMC-KL, Cornell.

[18] *The Ithaca Journal*, January 2, 1934, p. 3.

[19] Typed and signed copy, with corrections in pen. Gilbert D. Harris to Arthur C. Veatch, no date, but written in response to Veatch's letter dated October 25, 1915 which accompanied his donation. HA-PRI, Ithaca, NY.

[20] Gilbert D. Harris to Heinrich Ries, January 25, 1919, Heinrich Ries Papers, 14/15/691, Box 2, File 2-1. RMC-KL, Cornell.

[21] *Annual Report* by Heinrich Ries to Archie M. Palmer, May 23, 1923, p. 2. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[22] Perhaps it was never easy for Geological Sciences at Cornell, for a separate geology building, Snee Hall, was not dedicated until 1984 (Brice, 1989).

> of getting together most notable collections of materials and have no decent and safe building to put them in!"[23]

In his report to Ries for 1924–25, Harris emphasized why fire was such a concern to him:

> "What is most needed here is a suitable building and furniture and help in curator work. No human being can teach, carry on investigational work, be getting the important collections of this Hemisphere in his collections, and giving the results of his work to the world in completed printed reports, and at the same time have time to properly clean, shellac, number, catalog, and put away in convenient place for reference the thousand and one specimens from hundreds of horizons and thousands of localities. Nor is it economical that he should so spend his time. So far as our building is concerned it certainly taxes ones [*sic*] moral courage to be buying expensive books, getting in invaluable collections and feeling, with good reason, that every time the fire whistle blows a great share of ones [*sic*] interest in life may be going up in smoke. it seems as tho [*sic*] there must be some way out of this strange situation."[24]

Ries was cognizant of the situation and, again, made a point of stressing in his *Annual Report for 1924–1925* the value of Harris' collections:

> "The collections which he [Harris] has crowded on the top floor, can probably not be duplicated anywhere in this country, and are of great value for students interested in his particular field."[25]

The following year Harris was at it again:

> "What is most needed inpaleontologic [*sic*] geology here at Cornell now is a modest, compact, fire-proof museum building with a curator in charge."[26]

In none of the existing letters and reports written before the autumn of 1926 in which Harris spoke about the danger of fire and the need for fire-proof quarters does he suggest having such a building anywhere except at Cornell. But note the change in this letter from 1927:

> "Of course, the chronic disease, the stupefying factor here at Cornell in Geology today is the lack of facilities for the utilization of such materials as we already fortunately have.
>
> "Personally I am going into publication far more extensively than heretofore, but with more and better room could accomplish twice as much with half the energy.
>
> "I have sometimes seriously thought of removing everything not belonging to the University to an outside building, but have hesitated on account of desiring to *teach* by *doing* before the students themselves." [Emphasis in the original.][27]

In Harris' mind, the move had been made, and the reason seems clear; between the first letter quoted above (May, 1926) and the second (May, 1927), Harris and Maury had their confrontation (December, 1926), as detailed in a previous section. This change in Harris' mind from having all his collections at Cornell to leaving nothing at Cornell appears to have developed as a direct result of the Maury affair, and was an extension of his ideas on the need for a fireproof structure. In a portion of the 'apology' letter to the President in December, 1926, cited earlier, this transition can be pinpointed:

> "If necessary to protect the University from criticism *I can build some roomy apartment, off the University property* and collect therein ally [*sic*] my own and these various collections that might possibly cause embarrassments and hence relieve all anxieties."[Emphasis added.][28]

Even as he was contemplating a solution to his difficulties, Harris was still hammering away at the potential fire danger and Ries mentioned it again in his *Annual Report for 1926–27*, "The danger from fire is a menace which is continually with us."[29]

The following is yet another excerpt from a letter Harris wrote to Ries which further demonstrates his almost morbid fear of fire. Harris was writing on his own stationery, with the letterhead, "Paleontological Laboratory, Cornell University" and sending the typed letters to Ries; they were communicating by formal letter from one floor of McGraw Hall to another. In this letter Harris complained, again, about the fire danger, but used somewhat stronger language about moving his material elsewhere:

> "My amazement grows daily as I see heaps of ejectementa from the various geologic rooms and dens containing semi-burned matches by the hundreds and smell the odor of ignited tobacco.
>
> "Now there must be some way of stopping this matter. Of course these yongster [*sic*] who have nothing at stake care little, but if we have several tens of thousands of

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[23] Gilbert D. Harris to Heinrich Ries, May 2, 1924. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[24] *Annual Report for 1924–25* by G. D. Harris, N.D., pp. 1–2. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[25] *Annual Report for 1924–1925* by Heinrich Ries to R. M. Ogden, May 7, 1925, p. 3. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[26] G. D. Harris to Heinrich Ries, May 4, 1926. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[27] G. D. Harris to Heinrich Ries, May 24, 1927. Heinrich Ries Papers, 14/15/691, Box 1, File 1-23. RMC-KL, Cornell.

[28] Unsigned carbon copy of letter from Gilbert D. Harris to Livingston Farrand, President, Cornell University, December 16, 1926. HA-PRI, Ithaca, NY.

[29] *Annual Report for 1926–1927*, by Heinrich Ries to R. C. Gibb, May 28, 1927, p. 4. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

> dollars worth of types and rare publications needed in the promotion of science it is not fair to let this matter drag along unchecked, and I shall certainly see to it that my things, are disposed of elsewhere if Cornell does not show a vivid interest in not particularly my welfare, butthe [*sic*] welfare of sience [*sic*]."[30]

Ries looked into the situation immediately, and he did not let Harris get the better of him over the issue of fire hazards. As he explained in his reply, a quick inspection of McGraw revealed the worst potential for a fire to be in Harris's own paleontology laboratory:

> "If you will present me with a more exact information as to *where* you have seen these 'heaps of ejectementa' and 'semi burned matches by the hundreds', I shall be very glad to give the matter prompt attention. I have told you many times that no one is more worried over fire in McGraw than I am, and I also suspect that I keep a much closer watch over conditions in the entire department than you do, for I have the interest of the whole organization at heart, and realize that others besides yourself have irreplaceable collections.
>
> "Incidently, it may also be added that the fire inspector makes periodical visits to McGraw, and it was in your own rooms that he has reported some of the worst conditions. You may remember the time I visited the top floor with Mr. Curtis [the fire inspector], and in your northwest room found a lighted bunsen burner, perched on a narrow board over a bushel basket of waste paper.
>
> "[Handwritten at the bottom.] P.S. Possibly some of the fumes of ignited tobacco which you refer to may come from some of your own students who are known to descend to the floor below yours when they want to smoke." [Emphasis in the original.][31]

Yet, as indicated earlier, Ries was not unsympathetic to the need for better quarters. For years he had been trying, without success, to get the new and more fireproof facilities Harris, and he himself, wanted. In the 1919–20 report, after stating what an unfavorable impression the geology facilities made on visitors, he asserted that the department facilities were "actually *hindering the growth of the department*" [emphasis in original]. Ries had tried a different approach in 1923. As large enrollments forced the department to use the basement, in a letter to President Farrand, Ries complained that the area, ". . . is really not fit for women students to work in."[32] The university administration, however, apparently never seriously considered building new quarters for geology, even though President Farrand's 1931 report mentioned that this was "one of the real needs of the university."[33]

Given the animosity that appears to have existed between the two men, it would have been expedient for Ries to communicate to Harris what he was doing and that the fault of non-action did not lie with him or the Department, but it is difficult to tell if Ries told him or not. Harris did, however, know of Ries' attempts to make the University Administration aware of the situation in McGraw Hall. Monroe G. Cheney[34] appears to have sent Harris a letter he received from Ries in February, 1930, in which Ries described the needs of the department. At the top of Ries' list was the plea:

> ". . . we are sorely in need of a new building, in which we can feel safe from fire, . . . For some years I have stressed this matter as strongly as I knew how in my annual reports to the Dean, until he must be tired of hearing it, but I shall continue to do so."[35]

On the strength of that letter, just before a meeting of the American Association of Petroleum Geologists (AAPG) in New Orleans, Cheney sent an open letter to "Fellow Cornellians" (presumably only those who had connections with the Department) in which he outlined the problems and requested assistance. In this letter he had a long quotation from a letter he had received from Harris. Once again Harris put forth his idea about a having separate entity. Cheney quoted Harris as writing:

> "I would like to see a small, very substantial fire-proof section of a building commenced in this generation, with a possibility in the plan for future expansion. And I am convinced that the value of such a building would be such that the building and materials would be known and used by all real geologic investigators, Cornellians or otherwise. I think there is a way of inlisting [*sic*] real men in a real cause, *with no personal names* or strings tied to it." [Emphasis added.][36]

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[30] G. D. Harris to Heinrich Ries, April 20, 1928. Heinrich Ries Papers, 14/15/691, Box 1, File 1-23. RMC-KL, Cornell.

[31] Carbon copy, with handwritten P.S., Heinrich Ries to G. D. Harris, April 20, 1928. Heinrich Ries Papers, 14/15/691, Box 1, File 1-23. RMC-KL, Cornell.

[32] Heinrich Ries to Livingston Farrand, March 27, 1923. Heinrich Ries Papers, 14/15/691, Box 1, File 1-23. RMC-KL, Cornell.

[33] In a letter to "Fellow Cornellians", Cheney quoted Farrand as saying that, ". . . he [Farrand] considers that better geological quarters and facilities are among the foremost needs of the University." M. G. Cheney to Fellow Cornellians, March 8, 1930. HA=PRI, Ithaca, NY.

[34] Monroe G. Cheney (B.S. '16), later President, Anzac Oil Corporation, Coleman, Texas. The Monroe Cheney Fund was created at PRI by a donation from his widow in 1969.

[35] Heinrich Ries to M. G. Cheney, February 8, 1930, and bearing Ries' signature. HA-PRI, Ithaca, NY.

[36] M. G. Cheney to "Fellow Cornellians", March 8, 1930; copy sent to Harris attached to Ries' letter of February 8, 1930. HA-PRI, Ithaca, NY.

Note Harris' desire not to have a person's name on this new building or organization. Later, this was to play a major role when the final name for his new entity was decided.

The fear of fire, and his distaste for University involvement in what he obviously felt were his own affairs, appear to have planted the seed which in six years grew into reality. Yet PRI was nurtured by two additional conditions beyond his fears of both fire and not having total control of his own affairs and collections.

As Harris approached retirement, he had greater and greater anxiety about how to protect his collections and, at the same time, insure that the work to which he had devoted his life would continue. When Harris arrived at Cornell as a student in 1883, the center portion of McGraw Hall from the second to the fourth floors was devoted to a large museum. The museum is largely forgotten now at Cornell, but it was a substantial enterprise. At its peak, it included a large, three story, open gallery with a central atrium lined with balconies on the third and fourth levels. It housed many exhibits, both geological and non-geological, *e.g.*, several mounted specimens of recent animals and even a real Egyptian mummy (Brice, 1989). In addition to literally thousands of invertebrate fossils and Recent shells[37], the museum housed complete skeletons of fossil vertebrates, both real and full-sized casts, including a life-sized cast of a giant sloth skeleton. Harris had watched this University museum and its collections slowly disappear through neglect and indifference (Brice, 1989). Now as he neared retirement, he was faced with the prospect of having his life's work being similarly abandoned or at best not cared for properly:

> "I don't want to see my material, the work of 40 years, thrown into ash-cans. Furthermore, I want to be sure that the research will be carried on where I left off and that the collection will not fall into disuse in unsympathetic hands. After all, great cathedrals aren't built in a day or a year."[38]

So, this gave him another reason for having a separate facility; his fear of fire, the University having some control over who could or could not use the collections (exemplified by the Maury affair), and now his fear that no one would care for the material after he was gone.

But there is one more condition which, when added to the other three, helps explain his desire to create a separate entity, separate from Cornell or any other influence. This, furthermore, may have been at the heart of why there was such animosity and bad feeling toward Cornell on the part of Harris and both his real and his "paleontological" family; namely his perception of how he and his work was judged by the University administration and his colleagues.

Running through many of his reports and letters to Williams, Ries, and other University officials are statements which suggest Harris felt his work was neither fundamentally understood nor appreciated by his superiors. This is evident, for example, in his Annual Report for 1927–28:

> "I am well aware that all departments in the University could use to advantage more funds. But I say bio-geology should be considered first on account of what we have already personally done for its needs. The running of free excursions for 20 years by boat has not been duplicated by many departments, to mention but one item. The offering of ready means for publication of desirable paleontologic papers is not duplicated in every department. The use of photostat, type material, personal equipment in general, does not fall into the hands of students in every department."[39]

Earlier he had written:

> "We have had, therefore, to rely largely upon our own resources, chance associations with State and National surveys, special expeditions and various connections with exterior organizations for our support in our museum work and materials."[40]
>
> "And until some rather sweeping changes are made in plan of work, plan of announcements, teaching staff, quarters and appropriations I cannot look forward to great improvements here [at Cornell].[41]

Even in a newspaper article about the founding of PRI, there is the comment:

> "This cataloging and collecting Professor Harris has been doing for forty years, [was] all [done] at his own expense, [and] mostly with his own hands. . . . He bought the press with his own funds out of a salary that until ten years ago was not more than $1,500 a year. He worked extra in summer vacations to raise small sums for geology expeditions"[42]

This is a classic case of not telling the entire truth. Certainly what is in the article is true, but what it doesn't say is that the $1,500 represented only half-salary and that Harris himself requested the arrangements. But it seems Harris saw this article as an opportunity to tell the world how badly Cornell had treated him, and to demonstrate how unappreciated he was.

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[37] *e.g.*, The Newcomb Shell Collection which was originally purchased by Ezra Cornell and now resides at PRI.

[38] *Ithaca Journal-News*, April 1, 1933.

[39] *Annual Report for 1927–1928* by G. D. Harris for Heinrich Ries, May 8, 1928, p. 3. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[40] G. D. Harris to Heinrich Ries, May 2, 1924. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[41] Page 1, Annual Report by G. D. Harris to Heinrich Ries, May 4, 1926. Heinrich Ries Papers, 14/15/691, Box 2, File 2-4. RMC-KL, Cornell.

[42] *New York Herald Tribune*. Sunday, July 16, 1933.

Thus, is seems in Harris' mind he had four different, but related, pressures pushing him toward the eventual split with Cornell. It is interesting to note that the split was not total, however; for over 10 years after his retirement, Harris still maintained some quarters at McGraw. At least that seems to be the situation described by Ries:

> ". . . an investigation . . . [would] find that Professor Harris is now [1945] occupying considerably more space with his property than I am."[43]

The small platen press remained in McGraw Hall until 1948 (Palmer, 1982).

Starting as early as two years before his formal retirement from Cornell, Harris carried his idea to some of his former students, several of whom expressed their concern for the work at Cornell after he retired:

> "I am heartily in accord with the ideas expressed in your letter of February 20th regarding a building to be known as the 'Hall of Types.' "[44]
>
> "Whatever *is* going to happen to the department which you've spent so many fertile years to build up? Your last letter in which you mention that as yet no visible successor was being groomed for the paleontological department, frankly perturbs me. . . . My technique would be to stress what the department has done and in true alumnus style vigorously inquire what is going to be done when the old guard goes. Please let me know what your ideas are on the subject, for I feel we all owe it to you to first ascertain what *you* think is best, not only for the personal attachment but for the good of the department with the workings of which you are fully acquainted."[45] [Emphasis in the original.]

Not all of his former students seemed to feel a separate organization was altogether a good idea, Olsson wrote:

> "We have made such a start in Tertiary paleontology and it would be an everlasting disgrace if this work was suspended at Cornell in the future. Under the deplorable conditions in which the world finds itself today, the only thing we can do is to wait and hope for the best. . . . Until there is at least a change for the better and some assurance for the future, I personally believe that any other plan now would be sure to fail. This may not be a very bright picture to draw but all is not yet lost at Cornell and our first obligation is to her."[46]

But Olsson finally gave his blessing to the idea, although at the time he did not feel he could offer financial support:

> "I am very much interested in your new plans for your lab. [*sic*] and I hope you will be able to carry the project through to completion. In normal times as it was a few years ago, I could and would have considered it a privilege to take part in it but at the present time I can see no way of doing so. With taxes and other expenses continually rising from which there is no escape and no income, these times are very difficult and the prospect of any immediate change for the better is not rosy. However when I am once again on an earning bases [*sic*] I will be very glad to join your Paleontological company and become a share-holder. I have always dreamed of having a paleontological lab. [*sic*], but your idea is much finer than anything I could possibly visualize. There is no doubt that Cornell has got into a rut and intends to stay there. Still you have a year or more at Cornell and so there is really no need of rush or worry."[47]

In only a few short months, Olsson was to become a founding member of this new organization.

Harris worked with his family law firm in Jamestown, New York[48], to prepare a charter and a set of by-laws for a research institution. In the spring of 1932, Harris transferred title to a small strip of land on his property at 126 Kelvin Place that opened onto Dearborn Place to his new Institution, and the cornerstone for a future building was laid on June 28 of that year. This was marked with a simple ceremony, as might be expected of an occasion presided over by Harris. Each of those present inserted a particular object into the cinder block cornerstone, and, assisted by one of his graduate students, Stephen M. Herrick, (A.B.'27, M.S.'29, Ph.D.'33), Harris cemented it over. Participating in that historic event were Harris's wife, Clara, and their daughter, Rebecca; his friend, colleague, and neighbor, Professor A. C. Gill, and Mrs. Gill; Axel A. Olsson; three other former students, Pearl G. Sheldon, Beatrice Bolton (Mrs. Celton Hughes), and Katherine Van Winkle Palmer. The proceedings were watched over with great interest by Herrick's dog, Pat. Professor E. Laurence Palmer, husband of Katherine, took photographs and recorded the event on movie film, which resides in the PRI archives. Apparently within about a year, Harris had a small building in place over this new corner stone:

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[43] Heinrich Ries to Edmund Day, President, Cornell University. Heinrich Ries Papers, 14/15/691, Box 2, File 2-9. RMC-KL, Cornell.

[44] A. C. Veatch to Gilbert D. Harris, May 16, 1930. HA-PRI, Ithaca, NY.

[45] Norman Weisbord to Gilbert D. Harris, January 10, 1932. HA-PRI, Ithaca, NY.

[46] Axel Olsson to Gilbert D. Harris, March 17, 1932. HA-PRI, Ithaca, NY.

[47] Axel Olsson to Gilbert D. Harris, April 4, 1932. HA-PRI, Ithaca, NY.

[48] Wilson C. Price, Attorney and Counselor at Law, to Gilbert D. Harris, April 19, 1932. HA-PRI, Ithaca, NY.

> "Liddle was out to see me a few months ago and was much pleased with the Cabina [the name of the first PRI building]."[49]

Palmer (1982), however, indicated that the building known as the "Cabina" was not erected until late 1934, the year after Liddle saw the "Cabina" according to Harris' letter, and was not ready for occupancy until 1935:

> "After his retirement from teaching in 1934, he [Harris] financed the construction of a two-storied cinder black structure of 4800 square feet of four rooms with central stairway and fireplace . . ." (Palmer, 1982, p. 7).

Perhaps Harris meant to say that Liddle was pleased with the *plans* for the Cabina, or Palmer, who wrote the PRI history almost 50 years after the events, was simply confused about the dates, even though she was there when it happened. To further confuse the issue, in 1949 Harris himself said:

> ". . . in 1932, a small fire-proof [*sic*] structure was erected, and certain collections of fossils and books were installed." (Palmer, 1982, p. 22; Reprint of a letter to the PRI membership, May 1949).

This seems to support the idea that there was a building in place before he retired. In any case, the building was built, PRI was really underway, and the first official meeting in the Cabina took place on April 6, 1935.

The official Founding Members were Harris and his daughter Rebecca; former students (in order of their association with Harris), Axel A. Olsson, Pearl G. Sheldon, Ralph A. Liddle, Katherine V. W. Palmer; and Burnett Smith, a retired Syracuse University professor of geology and paleontology (Palmer, 1982).

After some wording changes in the Charter and By-Laws required by the Board of Regents of the State Education Department, PRI was granted a provisional charter on October 12, 1933, and a permanent charter was issued in 1936. Originally Harris had wanted to use the name *American Paleontological Institution*[50], but the State Education Department felt that this name was too broad and presented some misrepresentation (Palmer, 1982):

> ". . . the Regents do not approve of American Pal. Inst. as a name, fearing we are pretending to be more han [*sic*] we are, presumably. I have suggested other ways our but have failed. Still, maybe some of my last suggestions will carr , [*sic*] and Oct. i2th [*sic*] was the day they were o [*sic*] decide on charter granting."[51]

That name did appear in a newspaper headline atop an article about the founding of PRI which was published before the state charter was granted. The headline was "Harris' Museum of fossils Forms Nucleus of American Paleological Institution."[52] In another letter Harris used the name *American Institute of Paleontology*[53], which is close to the final name. Even though Harris used the word *Institute* in a letter, Palmer said:

> "It always annoyed Prof. Harris when the organization was referred to as the Paleontological Research 'Institute.' There is a difference [which Palmer did not explain]." (Palmer, 1982, p. 5)

As indicated earlier, Harris was adamant that neither his nor any other person's name be in the title of the Institution, and that there be no official connection with Cornell University (Palmer, 1982).

By the time the provisional charter was granted in 1933 the PRI had captured at least some of the media. Even the *New York Herald Tribune* had an article about it: "Museum built for Shell and Bone at Ithica [*sic*]"[54] quoted Harris as saying the reason for creating it was, "to keep safe some 'things money can't buy.'" The "things', according to the article were, "said to be part of life of 100,000,000 years ago."; the article didn't even get the age correct.

As an aside, it is interesting to note that in the conversations on which this article were presumably based, Harris appears to have used the word evolution:

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[49] Original letter, Gilbert D. Harris to "Hodsoni" [Floyd and Helen Hodson], October 15, 1933. HA-PRI, Ithaca, NY.

[50] The name appears in the photostat of a letter from Charles E. Weaver to Gilbert D. Harris, April 6, 1933. In the letter Weaver agrees with Harris that the arrangement is, ". . . an opportunity for the development of an organization where research may be carried on without restrictions of any University and for that reason it seems very desirable to have the entire plant off of University grounds . . ." HA-PRI, Ithaca, NY.

[51] Original letter, Gilbert D. Harris to "Hodsoni" [Floyd and Helen Hodson], October 15, 1933. Also in this letter Harris indicates that he had been ill for several weeks with kidney problems. HA-PRI, Ithaca, NY.

[52] *The Ithaca Journal-News*, April 1, 1933.

[53] This name is typed in capital letters at the top of an unsigned carbon copy of a letter, Gilbert D. Harris to "Dr. Bowen", March 12, 1933. This would be C. F. Bowen of Standard Oil Company as Harris received a letter from him June, 12, 1933, with a list of Brazilian fossils and the March letter was about Brazilian fossils. HA-PRI, Ithaca, NY.

[54] *New York Herald Tribune*, Sunday, July 16, 1933. The page and section are not known, for the article appeared in a regional edition, and that part was not included in the microfilm records which were of the "Final Editions" of the newspaper.

> "They [the fossils] are things which evolution discarded and threw out of the procession of life 100,000,000 years ago. Valuable because they are the last of their kind, records of 'horizons' of the past, essential pieces in a jugsaw puzzle which is expected some day to show man 'whence he came' "

This small statement is the only record known of Harris' thinking on the concept of evolution. Even in his historical geology text he did not go into the subject in any depth. In the Introduction he said:

> "If we are, as geologists claim, not children of an hour but of the tenth part of a second, geologically speaking, how can we presume to know the course of past and future ages of earth history? Is the life history of any organism whatever to be determined by a mere glance at its form at one stage of development? What botanist would attempt to write the life history of an oak if he never saw it except from the window of the Empire State Express?[55] What zoologist would feel competent to rush into print concerning the life history of a porpoise if he had observed it but once from out the cabin window of a Transcontinental steamer as the creature darted between two waves? But reflect for a moment, if along side a full grown oak the botanist could get a glimpse of oaks all the way from but a few inches in height to those already falling with decay, and the zoologist could see a whole school of porpoises of various sizes or stages of development, then the life histories of these subjects would no longer be so obscure although many of their earlier stages could only be surmised. . . . (Harris, 1907c, p. 3)

And in the section about the origin of life:

> "It is doubtless quite true that in general animals of simple structure preceded those of complex structure. The first forms of life were doubtless unicellular." (*Ibid*, p. 57).

From these excerpts from his text, it appears that Harris did at least agree with the idea of evolution. Exactly what he believed about the processes and mechanisms of evolution however, is unknown. Although in his text book he followed and described an evolutionary pattern of change in life forms, he apparently never published any general discussion of the topic.

When the time came to begin the transfer of samples from the Cornell Geology Department to PRI, confusion must have reigned supreme. Years earlier, a former classmate had remarked on the chaos in Harris' collections:

> "I am glad to learn that your are overhauling the plant material with the other fossils in the Museum. I hope you will turn up some interesting material. I dare say that there is a great lot of work to be done on your collections. When finished the fossil series will be far more efficient as a means of instruction for students."[56]

As the collections were divided, Ries had to shoulder the task of overseeing the collection separation and making certain that something was left for the University:

> ". . . because of Prof. Harris' retirement it became necessary to take stock of the collections on the top floor. As I [Ries] suspected they are in a most confused condition, and it will take some work to get them straightened out, for although some $1400 has been allowed for curatorial work on them during the past four or five years, little cataloging or arrangement of specimens has been done, in fact we had to depend to a large extent on Prof. Harris to tell us what belonged to the University and what to other people. I shall use the $200 allotted for curatorial work in the new budget towards making a start to get things in some sort of shape before a new professor is appointed."[57]

There was some truth to what Ries said about the lack of curation work with the fossils that were collected by the various expeditions. Apparently the groups would collect vast amounts of material, but then not have time to really prepare and describe what they brought back to the laboratory. Olsson (1914) and van Winkle and Harris (1919) used some samples collected on the 1897 *Ianthina* trip, 22 years later. And in 1921:

> ". . . more material from the '97 trip was found in the laboratory which had not been worked up." (Van Winkle, 1921, p. 352).

(Certainly Harris was not unique in being slow to get to material. For a thesis study (Howell, 1925), Harris loaned Princeton University several drawers of trilobites collected by C. F. Hartt in New Brunswick in the 1860s. These samples were not returned to Cornell until the 1980s.[58])

Even after some of the dust of Harris' move had settled, there were still problems concerning the collections. In Ries' mind, Harris had removed much more than necessary. Note the reference to course prerequisites, which was always a subject of contention between Harris and Ries:

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[55] The name of a fast passenger train of the day.

[56] David White to G. D. Harris, April 18, 1910. HA-PRI, Ithaca, NY.

[57] *Annual Report for 1933–34* by Heinrich Ries, N.D., pp. 2–3. Heinrich Ries Papers, 14/15/691, Box 2, File 2-17. RMC-KL, Cornell.

[58] These were returned to me after Snee Hall was opened in 1984. Princeton closed out paleontology and discovered the samples, still in the original drawers, with the Cornell labels on them. A friend was on the Princeton faculty then and knew of my connection to the Cornell Department and gave them to me at a Northeastern Section/ Geological Society of America meeting.

> "The courses in paleontology and stratigraphy are running satisfactorily, but they are handicapped by lack of study material, although Dr. Merriam[59] is attempting to overcome this trouble as rapidly as possible. I am glad to remark that he [Merriam] insists on his students having the proper prerequisites for his courses, so that is something I have not had to worry about since he took charge of the work in his branch. . . ."[60]

Several years later, Ries remembered the problems of collection ownership this way:

> "When Harris was about to retire an inventory was made of the property in Paleontology, whereupon it developed that of the 3300 odd drawers of fossils only about 1300 were acknowledged to be university property of which abut 3oo [*sic*] are practically of no value unless we can find the key to the letters on them. About 1300 [drawers] were listed by Harris as his property, while Caster claimed about 250, the remainder being said to be the property of various other people. It will be seen that the collection belonging to the university is wretchedly small. . . . He [Harris] removed all of his 'types' to his 'Institute' and with them went some of the types that belonged to the university, as was subsequently discovered accidently. A lot of Miss Maury's San domingo types have disappeared."[61]

To fully appreciate the step Harris was taking in starting PRI, one must consider the economic conditions of the nation at the time. 1932 was the height of the Great Depression; banks were failing by the hundreds, and bread lines were a common sight all across the nation. Yet, Harris went ahead with his dream, ignoring the pessimism of the day, for in his mind the alternative of leaving everything at Cornell was far worse. But it was, even then, a strange type of institution, for it came into existence with:

> ". . . no elaborate fanfare, no fund raising, no ballyhoo, nor subscription plan to start or promote the Harris concrete, but perhaps Utopian, scheme of a long term establishment. No private endowment funded or blessed this extremely informal modest enterprise." (Palmer, 1982, p. 5).

There is a certain irony in that as Harris was contemplating how he was going to raise the capital to put a building around his new corner stone, to Hodson he related the following:

> "Simonds writes they are moving in their grand Geol. bldg [*sic*], a building far finer that he ever dreamed of, and he has lived to see it. Texas is putting thru [*sic*] a $5,000,ooo.oo [*sic*] building program."[62]

In addition to his salary from Cornell and the fees he was paid by various oil companies, Harris apparently was renting the family farm[63] and he had subdivided part of the land, built houses on some of it and was renting them. According to surviving records, in 1939 Harris was selling land for $200 and acre and $250 for a corner lot[64]. Given the times, it is not surprising that he received the following letter; with a return address, "104 Harris Avenue":

> "I was wondering if it were possible for you to come down on our rent as I have had a fourteen 14.00 [*sic*] dollar a month cut in my salary and will be impossible for me to stay here at the present rate. I most assuredly hate to move from here as it is a very pleasant house & my wife & myself have become very much attached to it."[65]

And another letter, this time from "68 Harris Avenue":

> ". . . I deposited $25.00 to your account yesterday which is to apply for the month of Feb. and I will make another deposit for the month of March at a later date."[66]

As Harris approached the end of his time at Cornell, he began the transition from university professor to director of the private institution[67]. He converted the third floor of his house into a temporary laboratory and a new rotary cylinder printing press went into his basement. Later, as furnishings were purchased for the Cabina, Harris allowed only metal tables, chairs, and specimen cabinets as they would not burn easily. Finally he had his fire-proof building. Ironically, the only source of heat for the building was an open fire place. As the 1930s vintage concrete blocks were quite porous to the cold Ithaca winter winds, that fireplace was, no doubt, well used. The newspaper articles about the creation of PRI underscored the fire-proof aspect, but most did not get the name correct:

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[59] Charles W. Merriam, who replaced Harris (Brice, 1989).

[60] Heinrich Ries to R. M. Ogden, Dean, Cornell University, May 31, 1937, p. 2. This letter served as the Annual Report for 1936–1937. Heinrich Ries Papers, 14/15/691, Box 2, File 2-2. RMC-KL, Cornell.

[61] Undated notes prepared by Ries after Harris retired in 1934 and before Charles Merriam left in 1942. Heinrich Ries Papers, 14/15/691, Box 3, File 3-2. RMC-KL, Cornell.

[62] Gilbert D. Harris to Floyd Hodson, April 12, 1933. HA-PRI, Ithaca, NY.

[63] Cecil Card to Gilbert D. Harris, March 15, 1932. Mr. Card discussed the land taxes and electric bills he had paid, and requests Harris' presence to ". . . get the work for the summer planned, . . ." HA-PRI, Ithaca, NY.

[64] Unsigned carbon copy sent to Harris; Newman & Adams, Attorneys and Counselors, to William H. Feltcher, Jr., Esq., June 29, 1939. The letter was refusing an offer of $600 and outlining the prices Harris was asking. HA-PRI, Ithaca, NY.

[65] DeForest L. Strunk to Gilbert D. Harris, March 3, 1932. HA-PRI, Ithaca, NY.

[66] W. Edwin Carlson to Gilbert D. Harris, March 6, 1932. HA-PRI, Ithaca, NY.

[67] Although he was not officially elected to that office until June 2, 1950, everyone understood who was in charge (Palmer, 1982).

> "This institution, already chartered by the state board of regents, is established in a fireproof museum named by Professor Harris 'The Hall of Types,'[68] built with $3,000 of his own funds in the backyard of his home at 126 Kelvin Place."[69]

Certainly his former students appreciated the new facility, especially for its "fireproof" nature:

> "It is also of considerable satisfaction to know that our type material will be securely housed and properly cared for in the fireproof vault of the Paleontological Research Institution which Professor Harris has sponsored, to his everlasting credit. May this institution grow and prosper and ever increase in usefulness to students of paleobiology. May it also quicken interest in and appreciation for paleontologic research in the community in which it was established." (Flower and Caster, 1935, p. 200)

Not long after the beginning of PRI, Harris and a former student, Helen Tucker (Ph.D.'37; Mrs. Richards Rowland), had a serious disagreement, along the same lines as the situation with Maury. This one seemed to be centered around fossil collections that belonged to her which Harris wanted for PRI. Tucker appears to have come to Cornell about 1932. Among Ries' papers are letters of reference for her, and one is from Kirtley F. Mather of Harvard University.[70] She had attended a summer school course of his. One of Harris' former students, however, Ernest Rice Smith at Depauw University, had not had a very pleasant experience when she was in his department:

> "I don't believe you can realize the continual tension between Miss Tucker and me. It is terrible. I never saw the beat of that woman. For instance, I have the feeling that she has sent a student who was griping on me to the Dean. I'm not the only one who feels so, yet no one can prove it."[71]

> "I will be perfectly frank. We have been under such heavy expense this year together with decreased income I had even considered not coming to Ithaca myself this summer. yet I feel it very important for her sake, for my sake, for the sake of the department here, to move her on. How would you feel toward this? You urge her to try for the $300 scholarship there."[72]

Eventually she did come to Cornell to do work in paleontology with Harris. Shortly after she came to Cornell, her life was further complicated by the loss of all of her money when a bank failed.[73] In any event, she had difficulties and, given Smith's letters, in Harris' mind she no doubt came to Cornell under a cloud of suspicion. But despite all this, she and Harris appeared to develop a good working and personal relationship which lasted for several years. She was a Charter Member of PRI.[74]

Druid Wilson, a colleague of Tucker at Cornell, had known her at Florida Southern College prior to her coming to Cornell. He found her to be a good teacher, but not as careful with her research as she might have been. In fact Wilson said[75] he was unhappy with some errors in their first joint paper (Tucker and Wilson, 1932a), but he never saw the manuscript until it was too late to have his name removed. According to Wilson, the two of them were seldom in the field together, and he did most of the actual collecting, but they did publish a series of papers on Florida fossils (Tucker and Wilson, 1932b,c, 1933). So Tucker was active in paleontological research before and while she was at Cornell.

In 1935, she was granted Department funds to ship the fossils she collected in Florida back to Ithaca.[76] In addition she had amassed a collection of material from Cuba, and Harris apparently wanted these collections, which through some arrangement with him were stored in the basement of his house. He must have quoted her a price that was not even reasonable:

> "At no time has my Florida, Cuba, or any part of my other collections been offered for sale. If it were, I am too well informed in regard to the cost of collecting and transporting it to Ithaca to sell it for any such figure as you quote to me in your note. I do not see how you can advance

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[68] Harris used this name in a letter to Veatch in 1930, cited earlier.

[69] *The Post-Standard*, Syracuse, New York, November 4, 1934. The page and section are not known, for the article appeared in a regional edition, and that part of the newspaper is not included in the microfilm records which were only of the "Final Editions."

[70] Kirtley F. Mather to F. H. Richmeyer, Dean, Cornell University, March 7, 1932. Heinrich Ries Papers, 14/15/691, Box 1, File 1-61. RMC-KL, Cornell.

[71] E. R. Smith to Gilbert D. Harris, November 16, 1931. HA-PRI, Ithaca, NY.

[72] Personal letter, E. R. Smith to Gilbert D. Harris, February 23, 1932. HA-PRI, Ithaca, NY.

[73] Heinrich Ries to Eliot Blackwelder, October 5, 1941. Heinrich Ries Papers, 14/15/691, Box 3, File 3-3. RMC-KL, Cornell

[74] Helen Tucker is listed as a Charter Member in the minutes for October 6, 1934 (Palmer, 1982, p. 6).

[75] Personal communication, September 6, 1995.

[76] Heinrich Ries to Helen Tucker, July 22, 1935. Heinrich Ries Papers, 14/15/691, Box 1, File 1-61. RMC-KL, Cornell

> any suggestion that I might beowing [*sic*] you freight.[77] I am very certain such can not be the case. If you like, I shall be glad to consider any reasonable figure which you may quote for storage charges, even though you invited me to store the collections in your basement without any mention of such storage charges. I have the figure which Deans [a local moving and storage company] quoted to me at the time, and if you expect me to do so, I shall, of course have no choice but to try to raise the money somehow, [*sic*]
>
> "I should like to have an answer at once so that I can make arrangements to have the collections moved to-day, or to-morrow [*sic*] at the latest. Do you also consider that my types an [*sic*] other figured material should be removed from the collections of the Paleontological Research Institute? As I recall the matter, I have also a copy of Montfort[78] temporarily on deposit there.
>
> "I had hoped, and I still see no reason for this move on your part, that your feelings of bitterness against me might not lead to the point where it would involve scietific [*sic*] work or materials. However, it is your choice, and you very evidently do not care to explain the reasons for your actions.
>
> "Should you so desire, I shall be glad to send my fromal [*sic*] resignation as a charter member of your Institution. Feeling as you do at present I can see no reason for my attempting to clear up the present situation."[79]

What Harris wrote or said to her after receiving that first letter is unknown, but it certainly prompted immediate action on her part:

> "I think it is well for me to carry out the plan which I suggested to you in my first letter to-day [*sic*]—of removing all my collections and books from your basement and the Paleontological Research Institution. I have, therefore, arranged with Deans to bring me over at ten o'clock, Thursday morning, April 25th. I hope this will be convenient for you because it seems to be the only hour I am free that Deans can come. I hope that you yourself can arrange to there [*sic*] so that there may be no doubt in your mind in regard to the items which I remove.
>
> "I have number [*sic*] of boxes in the [Harris] basement; a book, a box of East Indian Permian, types and figured material in the Paleontological Research Institution which I shall arrange to have placed in a fireproof warehouse. I have no intention of making it impossible for workers here, or elsewhere, to study any of my specimens either now or in the future, but I do intend to avoid a repetition of a situation such as must have inspired your communication to-day [*sic*]."[80]

Several months later, she still had not located all her collections, and even some of her personal property. She wrote to Katherine Palmer:

> "I am returning the toaster, which I had never seen before it was left at the house. Mine was, you may recall, a large one with a rack, and in good condition. If it has been misplaced we will simply drop the matter.
>
> "You may also recall that I sent you a small barrel, i.e., a nail keg, of Indiana Salem (Mississippian) fossils, of which you have returned a mere handful of the material from which the fossils have been removed. Have they, also, been misplaced, or may I expect them to be promptly returned?"[81]

A few months later, Tucker, after removing all of her material, asked Harris for permission to study some of Olsson's Miocene types either at PRI, ". . . or to have Miss Schoonover[82] bring them to McGraw Hall for that purpose."[83] At this point Harris must have exercised his prerogative to select who would use the collections at PRI—one of the main reasons behind the creation of PRI—and he refused her permission to use the fossils. Tucker wrote to Harris in reply:

> "Last year I sent my resignation from membership in the Paleontological Research Institution. So far as I have been informed, no action was taken on the matter. Would [*sic*] it be unreasonable for me to ask for an immediate reply?
>
> "I have no wish to have my name connectend [*sic*] in any way with an an [*sic*] organization which refuses to cooperate with workers in other institutions, as I am informed yours does. Nor do I wish to be connected with an organization which seemingly attempts systematically to convey the impression that there is a connection between it and Cornell University and then fails to open its facilities to students in the University."[84]

So shortly after the creation of PRI, Harris was already exerting control over who could use its collections.

This first physical structure for PRI, "Block II" in Harris' long range plans ("Block I" was for some reason never built), as indicated earlier, was called the "Cabina" by all who labored there. Construction began in October, 1936 on "Block III", and by autumn of 1937, a second two-story structure was added, with a basement and a furnace so the open fireplace was no longer needed. According to the surviving records, "Block

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[77] In a previous letter Ries indicated the Department paid the shipping costs from Florida.

[78] A rare and valuable book on mollusks published in 1810.

[79] Helen Tucker to Gilbert D. Harris, April 23, 1935. Heinrich Ries Papers, 14/15/691, Box 1, File 1-61. RMC-KL, Cornell.

[80] Helen Tucker to Gilbert D. Harris, April 23, 1935. Heinrich Ries Papers, 14/15/691, Box 1, File 1-61. RMC-KL, Cornell.

[81] Helen Tucker to Katherine Palmer, September, 7, 1935. Heinrich Ries Papers, 14/15/691, Box 1, File 1-61. RMC-KL, Cornell.

[82] Lois (Schoonover) Kent.

[83] Helen Tucker to Gilbert D. Harris, January 28, 1936. Heinrich Ries Papers, 14/15/691, Box 1, File 1-61. RMC-KL, Cornell.

[84] Un-dated and un-signed copy of a letter from Helen Tucker to Gilbert D. Harris. Heinrich Ries Papers, 14/15/691, Box 1, File 1-61. RMC-KL, Cornell.

III" cost $4,187.01[85]. Although the Institution's Board of Trustees voted to expand the facilities in April, 1944, not until 1948, after the end of World War II, was "Block IV" added (Palmer, 1982). All three buildings were interconnected by a series of doors and steps, making it quite easy for the uninitiated to become lost trying to go from one room to the other.

The expanded Cabina became the home not only for Harris' collections, but also for his printing presses. From about 1934, even after the construction of the Cabina, until 1948, Harris printed his journals on a rotary-cylinder press that he had installed in the basement of his home. There was also a platen press still in McGraw Hall at Cornell University, where it had caused structural problems because of its weight and vibration. In 1948, both presses were moved into the basement of the PRI. Still preserved at PRI is the small platen press on which Harris did his original printing.[86]

PRI was not established as part of Cornell, and as an Institution, it has never had any official connection with the University; it is a separate scientific and educational organization. Not everyone has understood that fact. In Bishop's *A History of Cornell*, when describing changes at the University after world War II, he said:

> "The University took over the Paleontological Research Institution developed by Professor Gilbert Dennison Harris '86." (Bishop, 1962, p. 582).

The media announcements that accompanied the founding probably are responsible for much of this misunderstanding. One story was headlined with, "Harris Turns Over Museum to Cornell"[87], but then the article went on to say that the museum was constructed in his back yard. Ironically, in the late 1960s, when PRI moved to a new and much larger location at the former orphanage of the International Order of Odd Fellows on West Hill in Ithaca, the old PRI buildings on Dearborn Place were purchased by Cornell for additional storage and research space for the geology department.

In a letter to *Science* in 1934, Harris indicated his reasons behind the founding of PRI:

> "Facilities for the conserving of types have been hitherto lacking here; hence a fireproof building has been privately constructed and deeded to this institution . . .
>
> "There are three leading ideas underlying the establishment of this institution:
>
> "(1) To prevent the labor and valuable acquisitions of each generation from being wasted or lost, as is too frequently the case in educational institutions without proper museum facilities.
>
> "(2) To furnish temporary working facilities for paleontological students home from abroad or not connected with regular university or museum organizations.
>
> "(3) To serve as a regional center (since our country is large and not unicentric as is France) where local young students may see actual investigation going on and hence, perhaps, become interested in this branch of science." (Harris, 1934a, p. 381)

Yet, idea number (3) notwithstanding, for most of its history PRI has been essentially invisible to the local region. It existed behind Harris' house as a private domain for him, his students, and a few scholars who were involved in Tertiary paleontological research. Except for the postal workers who handled the journals when each issue was mailed, there was little community interaction. In many respects Harris was not fulfilling the spirit of the "educational" charter; in another he was doing exactly what he set out to do. Little wonder the local people have been so confused about PRI over the years.

In fact, according to Harris' own words, it was never his intention to include a real "public" aspect to his Institution's activities[88] beyond the occasional visit by school groups and local student clubs. In a talk Harris gave in June, 1939, to a group of natural history students visiting PRI, he revealed much about his perception of the Institution and why it was founded, and expanded somewhat on the ideas he had published in *Science* five years earlier. First and foremost, he still felt it was necessary to preserve collections gathered over 40–50 years of work, especially the generic and specific types, to keep the material from being "dumped in the ash barrel." The continuity of work could be assured by preserving the material, which required, of course, a fireproof structure. Harris felt that any educational institution becomes, essentially, the record of its graduates, and he wanted to preserve something to which the graduates could return. Such an organization would give the students an opportunity to do the necessary work to gain eminence in their field. In Harris' view, this could not be done without the proper institution, and his Institution was to be "of, by, and for paleontologists" and it would be limited primarily to Tertiary paleontology[89].

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[85] Statements from A. H. McPherson & Son, Contractors and Builders, January 5, 1937 and August 31, 1937. HA-PRI, Ithaca, NY.

[86] Personal communication, Dr. Katherine Palmer, July 28, 1982. The press was still at PRI in 1995.

[87] Newspaper and date are not identified, but it is assumed to appeared in the *Ithaca Journal* shortly after January 13, 1934 as the article was printed only a few days after the first Board of Directors Meeting which was held on that date. Heinrich Ries Papers, 14/15/691, Box 1, File 1-86.

[88] Beginning in the early 1990s, PRI began to improve its public role through an active association with the local public schools to improve earth science teaching though school visits, student field trips, and other educational programs, as well as expanded exhibits and educational programs at the West Hill building.

His statements in a letter to the PRI members in 1949 show that he had not altered his thinking during the ensuing 10 years. Indeed the 1949 letter echoes two of the four conditions which prompted him to create PRI 17 years earlier; namely having an organization not under the control of a larger entity, and preservation of collections. According to the letter, however, in Harris' mind PRI really started with the founding of *Bulletins of American Paleontology* in 1895, and the soul of the Institution was "research work", but he added:

> "The primal object of this Institution is to furnish a suitable retreat for those workers who desire to carry on investigations connected with their own collections, but who have no permanent affiliation with any large organizations, such as public surveys, museums, universities, etc. Since all work is pursued on a strictly voluntary basis, funds received (from sale of publications, membership fees, donations) can be applied to building, equipment, publication, and an eventual endowment fund.
>
> "A second, and by no means unimportant, function of this Institution is the preservation of paleontological materials that might otherwise be lost.[90] This applies, for example, to cuttings from wells in territories of abandon leases and collections from seldom-visited localities. The success in accumulating such collections and funds for their study and preservation will depend on the alertness of the members.
>
> "And, indeed, if the Institution itself is to continue and prosper, it will only be because of *a shared faith and feeling of responsibility*." [Emphasis in the original.] (Letter to PRI members by G. D. Harris, May, 1949; reproduced in Palmer, 1982, pp. 22–23).

Thus, PRI remains a unique institution, housing and caring for enormous fossil and Recent mollusk collections (the "type and figured collection" now exceeds 33,000 specimens; the non-type collections are estimated to contain more than 1.6 million specimens, placing them firmly among the 10 largest invertebrate fossil collections in the United States[91]). Until recently, few people ever saw this material, however, for public exhibit space in the West Hill building is minimal[92]. PRI publishes several scholarly publications, but is not an academic organization in the conventional sense, for it depends heavily on volunteers, and operates with only a small number of paid, full-time staff supporting its activities. PRI continues to be the world's only private organization devoted solely to advancing and preserving the science of paleontology, an increasingly important role at a time when many universities are closing or reducing their paleontology programs.

In 1984, after the last surviving member of the party who laid the cornerstone had died, Peter Hoover, then the Director of PRI, and I decided it was time to open the cinder-block cornerstone. If it contained anything of historical interest, we felt, it would be better to remove and preserve those items than to leave them in the block that had become quite porous with age. Accordingly, on July 19, 1984, Dr. Hoover carefully opened the cinder block cornerstone in the presence of several very interested people. Inside were the badly deteriorated remains of the envelopes that held the articles deposited by those who were present at the laying of the stone.[93]

All but one person had deposited a Tertiary fossil in an envelope, and on each envelope they had written both the name of the fossil and his or her own name. Naturally enough, Harris's fossil was *Ecphora*, the symbol of the PRI and the name he gave to his last boat. Rebecca Harris, his daughter, was the only one who did not use a fossil for her remembrance. Instead, she placed a small Joan of Arc medallion in the cinder block, and with it was a card on which she had written:

> "Joan of Arc also saw visions and dreamed dreams."

Those were, and still are, fitting words, for her father's dream did come true. Through the dedication, loyalty, and sheer hard work of his students, friends, and fellow paleontologists, the publications and the Paleontological Research Institution he began are alive and well as we near the end of the Twentieth Century.

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[89] Although the complete text of the Harris talk no longer exists, a student, Lois Schoonover, later Mrs. Lois Kent, took detailed notes and these notes are the source used for the information in this paragraph. All quotations are from these notes. HA-PRI, Ithaca, NY.

[90] As late as the last two decades of the Twentieth Century, drawers of fossils still were being transferred from the Department of Geological Sciences at Cornell to PRI. Harris' fear of what might happen to the department collections in later years has become a reality, but fortunately, his PRI exists to save the material.

[91] Warren Allmon, person communication, August 1, 1995.

[92] During the summer of 1995, PRI created a temporary public exhibit of material in a building on The Commons in downtown Ithaca. The centerpieces of the exhibit were mechanical dinosaur models, but accompanying materials came from PRI collections and the PRI staff designed the entire exhibit. All told, more than 100,000 people viewed PRI exhibits or participated in Institution-sponsored programs in 1995. A fund drive for a suitable public museum has been started.

[93] The articles removed are now in the PRI Archives.

CHAPTER 10. FINAL WORDS

Gilbert Dennison Harris rose from humble beginnings on a farm near Jamestown, New York to be one of the premier paleontologists of his day. Through his students, publications, and professional consulting, he had a major impact on our understanding of the fossils and stratigraphy of the Tertiary rocks of the Atlantic and Gulf Coastal Plains. Harris had great energy for doing paleontological research; he was really able to go out and "get the job done", efficiently and quickly. During one trip late in his career, as he and Palmer were doing some roadside collecting they were managing to stay ahead of a road crew seeding the road cuts right behind them[1]. This enthusiasm he passed along to his students. According to Druid Wilson, few people have ever traced a single unit for over 1,000 miles as Harris did, and Wilson feels he deserves a place alongside Conrad, Aldrich, Lea, and others, as one of the all time giants of Tertiary paleontology[2]. Certainly some of his paleontological publications set a standard for the profession, and several of his papers are still considered the definitive work for particular groups of fossils or time intervals. The primary key to his good work rested in the fact that Harris was a good illustrator who supported his illustrations with the appropriate descriptions[3]. Even today, many, perhaps most, of the species that he first described are still considered valid.

Once, when asked late in his life how he would like fellow geologists to think of him, Harris replied, perhaps with false modesty, "As a beginner in a limited number of branches of geologic sciences." And when asked were there any particular personal features he would like to be remembered, he offered two:

> "Building of boats for geologic excursions before the days of automobiles[.]
>
> "Establishment of the Paleontological Research Institution at Ithaca for volunteer research workers [.]"[4]

Of all his accomplishments, these were the most personal to him.

Based upon their success, for most of his students Harris fulfilled the role of mentor in the finest tradition of the word. For a student seeking training in the field of paleontology as it existed 50 to 100 years ago, he or she could have done no better than to train under Gilbert Harris. At the time there were few places where students, even before they completed their studies, had the opportunity to serve in responsible positions with a state geological survey, but Harris' students could do just that while he headed the Survey for the State of Louisiana. And the fact that the professor had his own journal and was willing to publish student work, gave these students an almost ideal situation.

Yet, Harris was an enigmatic person; kind and generous, a wonderful mentor, and lasting friend, he could also be vindictive, mean, self-centered, and just downright ornery. In a few words, he was human. His legacy to paleontology lives on through his publications, the work of his students and his students' students and their students as the torch has been passed from generation to generation. But mostly his bequest to posterity is kept alive most tangibly though his journals and the Paleontological Research Institution which he founded in 1932. During the Depression, a time when most people were wondering how they would survive another day, Harris was looking to a future beyond the present misery. He was able to infect others with his dream of the future, and that small band of followers gathered one warm afternoon in June on a plot of land behind his house, and in the form of a cinder block, laid the beginning of that dream.

As a student at Cornell Harris had the benefit of studying under Henry S. Williams, and some of his success as a teacher he owed to what he learned during his time with Williams. But Harris mostly learned by doing and he expected his students to follow that path, and many who followed his path found that it led to foreign shores. From Venezuela a student wrote to Harris:

> "I certainly appreciate the training you gave me and your help in getting me started in Paleontological work."[5]

Not everyone reacted well to this style of teaching, but those that did went on to make their mark in the world of paleontology; his students included Kenneth E. Caster, Monroe G. Cheney, Herdman F. Cleland, W. Storrs Cole, Stephen M. Herrick, Floyd Hodson, Charles W. Honess, Lois M. (Schoonover) Kent, Edward Kindle, Henry Leighton, Ralph A. Liddle, Carlotta J. Maury, Axel A. Olsson, Joviano A. A. Pacheco, Katherine V. W. Palmer, Irving Perrine, Charles S.

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[1] David Dockery, personal communication July 12, 1995.

[2] Druid Wilson, personal communication September 7, 1995.

[3] David Dockery, personal communication July 12, 1995.

[4] Question included in Walter E. Hopper to Gilbert D. Harris, July 1, 1950; answers included in unsigned carbon copy, Gilbert D. Harris to Walter E. Hopper, July 5, 1950. HA-PRI, Ithaca, NY.

[5] Floyd Hodson to Gilbert D. Harris, January 7, 1932. HA-PRI, Ithaca, NY.

Prosser, Percy E. Raymond, Leopold Reinecke, John L. Rich, Helen I. (Tucker) Rowland, Pearl G. Sheldon, Ernest R. Smith, Arthur C. Veatch, Walter A. Ver Wiebe, Norman E. Weisbord, John W. Wells, Francis L. Whitney, Druid Wilson, and Charles Yeakle, just to mention a few.

Harris also touched the lives of many who never majored in paleontology, but only had a class or two with him. Almost 35 years later they still remembered vividly their brief encounter:

> "You can scarcely be likely to remember me—just one of your elementary students of about 1913. I mean I took the lecture course in elementary paleontology up in your laboratory high in Mc Graw [*sic*], also your course in Geologic Mensuration and still have the notes! I also have a photo of you at the steering lever of your Cayuga Lake vessel." [Emphasis in the original.][6]

In many ways Harris was a driven man; he was not a person who could sit still for very long, even in "retirement." At age 73 he visited the University of California to study the Tertiary of the west coast. He celebrated his 82nd birthday while on a collecting trip to Florida, Alabama, and Georgia (Palmer, 1953c) which totaled over 3700 miles and lasted almost a month. Right up to his death he was actively engaged in paleontological research. His last paper was published just a few months before he died (Harris, 1951), and in part was based upon the samples collected during his recent excursions to the south. Well past his 80th birthday, he was still running the presses to print his journals. Perhaps Harris described it best with his Christmas Greeting sent in his 85th year:

> "We are happiest when our hobbies and our 'life's work' become identical." (Herrick *et al.*, 1953, p. 16A).

Katherine Palmer, who worked with Harris from 1921 until his death in 1952, remembered him thusly (Palmer, 1953b, p. 2624):

> "He was always stimulating and inspiring to those students of close contact and he continually planned training and provided opportunities for their scientific advancement. In turn he received steadfast loyalty and developed an idealism which is manifested in the projects which they in turn initiated or helped carry on. The monuments of basic endeavors which Professor Harris built along the way in paleontology and stratigraphy are bench marks from which the progress of those sciences can be measured. The worth of such factors is everlasting."

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PLATES

Plate 1.—Gilbert Harris in May, 1872, age 8. (Photo: HA-PRI, Ithaca, NY.)

Plate 2.—Gilbert Harris, ca. 1895, shortly after he began teaching at Cornell. (Photo: HA-PRI, Ithaca, NY.)

Plate 3.—Field crew from the Louisiana Geological Survey, 1905. Harris is second from the right. (Photo: HA-PRI, Ithaca, NY.)

Plate 4.—Harris at a tide gauge station near Weeks, Louisiana, 1905. (Photo: HA-PRI, Ithaca, NY.)

Plate 5.—Harris (bent over on the stern) inspects his new launch *Ecphora* at Champaign's Dock in Ithaca, 1914. (Photo: HA-PRI, Ithaca, NY.)

Plate 6.—Harris' launch *Ecphora*, Cornell pennant on the bow, passing through a lock on the Erie Canal, 1914. (Photo: HA-PRI, Ithaca, NY.)

Plate 7.—Harris at the helm of his launch *Ianthina*, date unknown. (Photo: HA-PRI, Ithaca, NY.)

Plate 8.—Class field trip to Yawger's Woods, on the shore of Cayuga Lake, ca. 1927-28. Harris is seated, right foreground. (Photo: HA-PRI, Ithaca, NY.)

Plate 9.—Harris and his students around the table in McGraw Hall, Cornell University, probably ca. 1915-1920. Left-to-right: A. Jacot, Karl Schmidt, Carlotta Maury, Harris, Axel Olsson, and E.R.Smith. (Photo: HA-PRI, Ithaca, NY.)

Plate 10.—A more formal (and possibly posed) photo, around the table in McGraw Hall, ca. 1921. Left-to-right: Axel Olsson, Harris, Pearl Sheldon, Carlotta Maury, Katherine Van Winkle Palmer. (Photo: HA-PRI, Ithaca, NY.)

Plate 11.—Carlotta Maury in the paleontology laboratory in McGraw Hall, date unknown. (Photo: HA-PRI, Ithaca, NY.)

Plate 12.—June 28, 1932, the cornerstone of the first building of the Paleontological Research Institution is laid near Harris' house on Dearborn Place in Ithaca. In rear, left-to-right: Axel Olsson, Katherine Palmer, Mrs. A.C.Gill, Beatrice Bolton, Rebecca Harris, Pearl Sheldon, Clara Harris, Prof. A.C.Gill. Foreground, Stephen Herrick (left) helps Harris set the stone. (Photo: HA-PRI, Ithaca, NY.)

Plate 13.—Harris' official faculty photograph, taken around the time of his retirement from Cornell in 1934. (Photo: Department of Manuscripts and University Archives, Cornell University.)

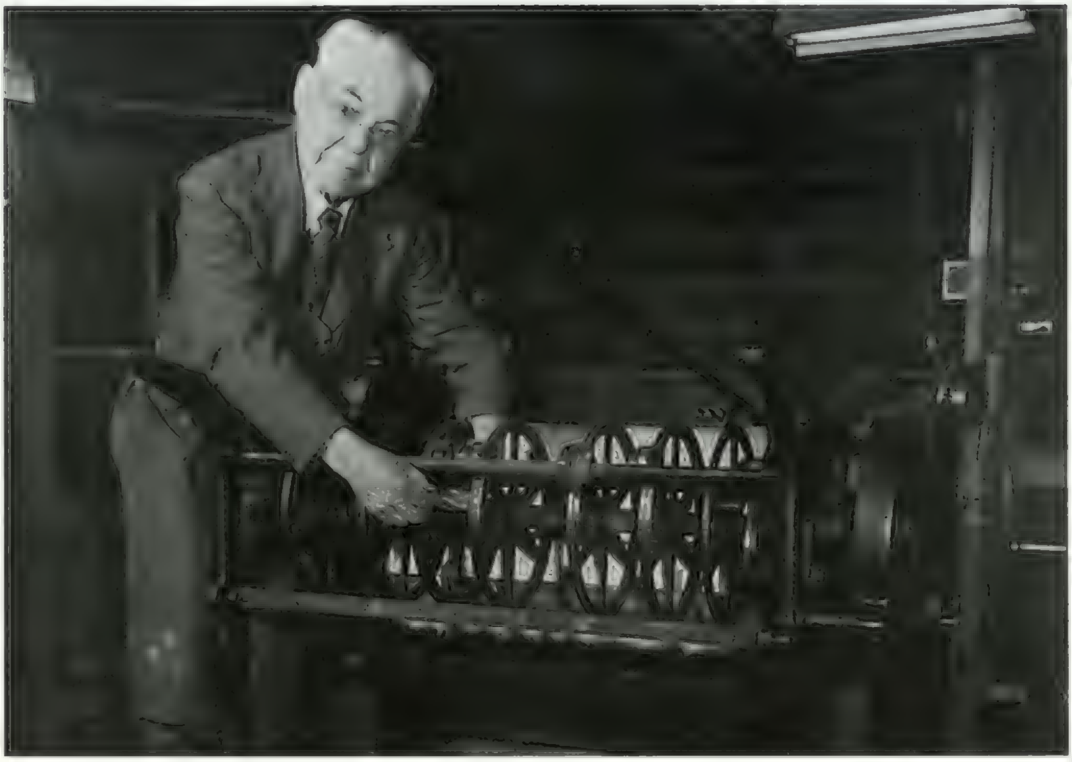

Plate 14.—Harris, age 85, with his rotary printing press in the basement of the Paleontological Research Institution on Dearborn Place in Ithaca, November, 1949. (Photo: HA-PRI, Ithaca, NY.)

INDEX OF PEOPLE

NOTE: As the biography is about G. D. Harris, his name does not appear in the index.

Page numbers marked with * means the reference is in a footnote on that page. Where there are multiple pages listed, *e.g.*, 120–125, please check the footnotes on those pages for references to the person.

Adams, C. K., 36
Adams, Frank, 118*
Agassiz, Louis, 43
Alexander, Charles P., 59, 60
Allen, Catharine M., 72*
Allen, J. F., 72
Allmon, Warren, 8, 129*
Anderson, J. M., 72*
Andrews, Avery D., 94, 94*, 95, 95*, 100, 100*
Anzalone, Michael, 9*
Arias, Desiderio, 93

Barrows, Rev. E. B., 22
Bauer, L. A., 64*
Berliner, Emile, 92
Blackwelder, Eliot, 126*
Bloom, Arthur L., 91*
Bolton, Beatrice
  (Mrs. Celton Hughes), 122, Pl 12
Boyd, Thomas D., 110–111
Bowen, C. F., 85*, 123*
Branner, John C., 11, 12, 13, 31, 32, 33, 35, 35*, 69, 69*, 89, 92, 92*, 109–111
Brice, Heather W., 9
Brice, William R., 7
Brown, Larry, 46
Brunberg, Nancy, 8
Bullbrook, J. A., 85*
Burfoot, James, 45
Burns, Fank, 23

Caine, Thomas A., 47, 51
Card, Cecil, 117*, 125*
Carlson, W. Edwin, 125*
Caster, Kenneth, 42, 43, 54, 130
Cheny, Monroe, G., 75*, 120, 120*, 130
Cheny, W. D., 75, 75*
Chiment, John, 118*
Clarke, John Mason, 41, 91, 91*
Clarke, W. B., 23, 38
Cleland, Herdman F., 40, 51, 130
Clendenin, William W., 63
Clinton, DeWitt, 43
Cole, Storrs, 8, 46, 130
Colman, Gould P., 8
Comstock, John Henry, 40
Compstock, Theodore, 46, 49
Conable, Charlotte, 45
Conant, Georgianna Duncan, 46
Condit, D. Dale, 82*, 86
Conrad, Timothy Abbott, 23, 32, 34, 34*, 35, 35*, 38, 39
Conway, Jill Ker, 45
Cook, Lillian, 21
Crandall, 91
  Christina (Benjamin), 9
  Lydia—See Harris, Lydia
  Stephen, 9
Crane, Thomas F., 53, 53*, 54
Cumings, Edgar R., 47

Dall, William Henry, 13, 14, 18, 22, 23, 24, 30, 31, 32, 32*, 35, 35*, 37, 54
Dana, James Dwight, 11, 12, 35, 36, 37, 38, 38*
Davis, A. C. (Dave), 62
Derby, Orville A., 36, 46, 46*, 89, 91, 91*, 92
Dockery, David, 130*
Dodson, W. R., 68, 68*, 69, 69*, 70, 70*, 72, 111
Doheny, Edward, 104*
Doty, Emily
  See Harris, Emily (Doty)
Dumble, E. T., 33, 34, 39*

Eaton, Amos, 52
von Engeln, Oskar D., 45, 45*, 114–115

Fall, A. B., 104*
Farrand, Livingston, 84*, 96–105, 108*, 119, 119*, 120*
Feltcher, William H., 125*
Flower, Rousseau, 117
Gabb, William, 92, 92*
Galloway, J. J., 38*
Gardner, Julia, 18
Ghandi, M., 86
Gibb, R. C., 119*
Giddens, T. K., 78, 79, 79*
Gilbert, G. K., 29
Gill
  Adam C., 6, 37, 106–107, 111*, 117, 122, Pl 12
  Mrs., 122, Pl 12
Graton, L. C., 118*
Gregory, H. E., 12
Grinnell, Lloyd G., 56, 56*, 57, 58, 59
Gumbel, H. E., 66*
Gumble, 77
Guppy, Robert John Lechmere, 39, 39*

Hall, James, 41, 52
Halliday, S. D., 106*
Harris,
  Clara (Stoneman) (wife), 6, 12*, 14, 14*, 15, 15*, 16, 16*, 17, 17*, 18, 18*, 19, 19*, 20, 20*, 21, 21*, 22, 22*, 23, 23*, 24, 24*, 25, 25*, 26, 26*, 27, 27*, 28, 28*, 29, 29*, 30, 30*, 31, 31*, 33, 46, 117, 122, Pl 12
  Cora Ethel, 9, 14, 14*, 15, 15*, 21*
  Emily (Doty), 15, 24, 28
  Florence Bell; See Floy Bell
  Floy Bell, 10, 10*, 13, 13*, 14, 14*, 15*, 18*, 20, 21*, 31, 31*, 54*
  Francis E. (father), 9, 14, 15, 16, 20
  Gabriel, 9
  Gilbert, (Uncle of G. D. Harris), 9
  Ida Christiana, 9, 9*, 14, 14*, 20*, 31, 31*
  Jane (Bruce), 9

  Jennie May, 10
  John, 9
  Jonathan, 9
  Lucy (Miller), 9
  Lydia Helen (Crandall) (mother), 9, 14*, 15, 15*, 18*, 21
  Oscar, 9
  Randolph, 10
  Rebecca Stoneman (daughter) 24, 30, 33, 46, 54, 105, 17, 122, 129, Pl 12
  Robert (name used for baby before birth), 26, 29
  Rollin Arthur, 10, 10*, 14, 15, 20, 25, 28, 56
  Samuel, 9
  S. D. (really G. D.), 13
  Walter, 9
  William, 9
Hartt, Charles Frederic, 12, 12*, 36, 43, 46*, 61, 61*, 89, 124
Hathaway, O. C., 69*, 77, 78, 79
Hayes, C. M., 67*
Helverson, Ralph N., 21, 21*
Henderson, Julius, 89, 90, 90*
Herrick, Glenn W., 116*
Herrick, Stephen M., 122, 130. Pl 12
Hicks, C. M., 66, 66*
Hill, N. F., 83*
Hill, Robert T., 11
Hodge, Thomas L., 77, 78, 78*, 79, 79*, 80
Hodson (Hodsoni), 96, 117*, 123*
  Floyd, 85, 87, 98, 98*, 99, 99*, 125, 125*, 130, 130*
  Helen, 87, 98*
Hollick, Arthur, 64
Honess, Charles W., 130
Hopkins, E. B, 65
Hooper, Walter E., 70, 70*130*
Hoover, Peter, 129
Hubbard, Walter Stacy, 49, 49*

Ingalls, Albert G., 130*

Jonlaw, William, 77*
Jordan, David Starr, 11
Jordan, Teresa E., 45
Jordy, J. Numa, 71, 71*
Journee, H. M., 73, 73*, 74, 74*, 75, 75*, 76, 76*, 77, 78, 78*, 79, 80, 80*, 81, 81*

Kaufmann, Carl B., 116
Kellogg, Peter Paul, 62, 62*
Kent, Lois (Schoonover), 107*, 116*, 127, 127*, 129*, 130
Kierstead, Caroline Heminway, 45*, 46
Kimball, M. C., 59*
Kindle, Edward M., 40, 109, 130
Knapp
  Arthur, 72
  I. N., 72, 72*
  Vivian L.
  (Mrs. Arthur Knapp), 72*
  Walter, 72
Kugler, H. G., 84, 84*, 85*, 116*

Leighton, Henry, 107, 107*, 108*, 130
Lerch, Otto, 63
Liddle
  Ralph Alexander, 83*, 84, 85*, 85, 117, 123, 130
  Pearle, 117
Long, Eleanor, 56

Lounsbery, Dean E., 85, 86*
Lucas, Capt. A. F., 65
Lyell, Charles, 52
Lyford, C. A., 81, 81*

Martin, George C., 46
Martin, George M., 116*
Mather, Kirtley F., 126, 126*
Maury
  Antonia Coetana P. P., 91, 91*
  Carlotta, 6, 39*, 46, 83, 85, 89, 90–105, 130, Pls. 9–11
  Matthew Fontaine, 91
  Mytton (Rev.), 91
  Sarah, 91
  William, 91
McAndrews, John H., 91*
McDonald, D. F., 82
McCarthy, Mary, 5
McGee, Ann 44*
Merriam, Charles, 125, 125*
Merritt, Ernest, 40
Miles, Frederick F., 72*, 81
Miller, Walter L., 118*
Monnett, Victor Elvert, 56, 57
Morgan, Col. Edwin B., 61*

Newell, F. H., 66, 66*, 67, 67*
Nevin, Charles M., 45, 46, 101*, 104*, 106*, 107*, 109*, 114*, 116*

Ogden, R. M., 108*, 125*
Olson, Oliver N., 56, 57
Olsson, Axel A., 42*, 48*, 52, 52*, 56, 56*, 59, 59*, 60, 65*, 82, 82*, 87, 87*, 89*, 90, 92, 92*, 93, 95, 96*, 117*, 122, 122*, 123, 130, Pls 9, 10, 12

Pachecho, Joviano, 48, 48*, 51, 52, 53, 67, 68*, 130
Palmer
  E. Laurence., 117, 122
  Katherine (Van Winkle) 12*, 39, 41, 42, 42*, 43, 46, 62*, 90, 95, 95*, 105, 117, 122–123, 127, 127*, 128*, 130, 131, Pls. 10, 12
Pardee
  Ario, 76, 79
  C., 76, 76*, 77, 77*, 78, 78*, 79, 79*, 80, 80*, 81, 81*
  W. B., 94*, 95, 96, 96*
Parker, J. M., 3rd, 116
Perrine, Irvin, 55*, 82*, 130
Petersen
  Francis Eugene, 9*
  Ida (Harris)
  See Harris, Ida
Pilsbry and Johnson, 93
Price, Wilson C., 122*
Prosser, Charles S., 12, 12*, 13, 22, 29*, 31, 35, 131
Powers, Sidney, 69, 69*

Raleigh, Sir Walter, 60
Raymond, Percy E., 40, 50*, 131
Reinecke, Leopold, 48, 52, 65, 65*, 131
Rehn, James A. G., 117*
Rich, John L., 42, 42*, 48, 48*, 52, 52*, 53, 65, 65*, 131
Richmeyer, F. H., 126*
Ries, Heinrich, 6, 33*, 39*, 46, 46*, 47*, 53*,

56, 59, 59*, 61, 62, 62*, 64, 89, 89*, 90, 90*, 92*, 93*, 94*, 96–114, 118–121, 124–127
Robinson, Emma C., 54, 54*
Ruedemann, Rudolf, 41

Sage, Lillian Belle, 50, 50*
Say, Thomas, 39, 39*
Schmidt, Karl P., 56, 56*, 57, 58, 59, 59*, 60, 61, 82, 82*, 92, 92*, 93, 108, 108*, 110. Pl 9
Schulz, Charles, 77*
Schurman, Gould, 5, 35, 35*, 36, 36*, 37, 37*, 49*, 53, 56, 56*, 59, 59*, 62, 81, 81*, 92*, 106, 106*, 107, 107*, 110–113
Schoonover, Lois
  See Kent, Lois
Sheldon, Pearl G., 41, 56, 122–123, 131, Pls. 10, 12
Sheperd, Henry, 71*
Simonds, Frederick W., 12, 13, 13*, 29, 29*, 125
Sinclair, Harry, 104, 104*
Smith, Albert W., 89, 89*, 90
Smith, Burnett, 123
Smith, Charles E., 52, 60
Smith, Edwin, 67
Smith, Ernest Rice, 56, 58, 59, 126, 126*, 131, Pl 9
Soper, R. H., 83, 83*
Stanton, T. W., 31, 31*, 64
Stoneman
  B., 16
  Basie, 17, 21, 23, 24, 26, 27
  Bertha, 16, 17, 17*, 117–118
  Byron, 22
  C., 16
  Clara-See Harris, Clara
  Marian, 16, 17, 27, 31
Strunk, DeForest L., 125*
Stubbs, William C., 63, 66*, 68, 68*, 70, 71, 71*, 72
Sunball, Henry R., 56

Tarr, Ralph S., 6, 35, 36, 36*, 37, 40, 59, 91, 106–107, 111, 111*
Taylor, Bayard, 59, 60
Taylor, Rev. Walter, 21
Thompson, James D., 59, 60, 61
Thro, W. E., 51
Tracy, C. A., 53
Treman, R. H., 106*
Tucker, Helen (Mrs. Richard Rowland), 126–127, 131
Tuttle, Edward M., 42*

Van Winkle, Katherine
  See Palmer, Katherine
Veatch
  Arthur C., 44, 44*, 50*, 51, 53, 55, 55*, 63, 64, 66, 66*, 79*, 83, 83*, 86*, 87, 87*, 118, 118*, 122*, 131
  Caroline Hornbrook (Evans), 45
Ver Wiebe, Walter A., 131
von Engeln, O. D. See under E

Walcott, Charles D., 13, 33, 33*
Ward, Lauck W., 18, 19
Waring, Gerald A., 83, 83*, 84, 84*, 85*
Weate, Blance Ames, 20
Weaver, Charles E., 123*
Weeks, Lewis George, 86*
Weisbord, Norman E., 87, 88, 88*, 89*, 95, 95*, 122*, 131
Weller, Stuart, 12
Wells, John W., 7, 8, 42, 42*, 46, 91*, 107*, 131
Wexler, 76
Whitaker, M. M., 55
White, Charles David, 11, 12, 29*, 31, 31*, 124*
White, C. A., 105
Whitney, Francis L., 33, 48, 49*, 52, 53, 54*, 65, 65*, 131
Williams
  Henry Shaler, 12, 13, 22, 35, 36, 36*, 37, 38, 42, 43, 51, 52, 52*, 107–115, 121, 130
  Roger B., 55, 55*, 70, 70*
Williams, J. Francis, 37, 37*
Williams, Samuel Gardner, 11
Wilson, Druid, 18, 18*, 19, 32, 107, 126, 130, 130*, 131
Wilson, Woodrow, 5
Wong, Parkin, 56, 57
Wright, A. M., 116*

Yeakle, Charles, 131

PREPARATION OF MANUSCRIPTS

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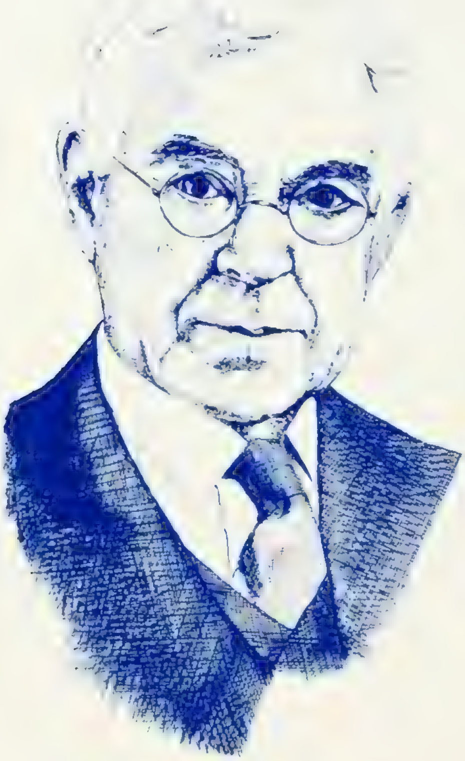

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Neogene Paleontology in the Northern Dominican Republic

16. The Family Corbulidae (Mollusca: Bivalvia)

by

Laurie C. Anderson

17. The Families Cuspidariidae and Verticordiidae (Mollusca: Bivalvia)

by

Peter Jung

Paleontological Research Institution
1259 Trumansburg Road
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CONTENTS

16. The Family Corbulidae (Mollusca: Bivalvia)

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Page

- Abstract 5
- Resumen 5
- Introduction 5
- Acknowledgments 6
- Biostratigraphy and Paleoecology 6
- Biogeography 11
- Abbreviations of Repository Institutions 11
- Systematic Paleontology 11
  - Introduction 11
  - Systematics 12
  - Family Corbulidae Lamarck, 1818 12
    - Subfamily Corbulinae Lamarck, 1818 12
      - Genus *Corbula* Bruguière, 1797 12
        - Subgenus *Bothrocorbula* Gabb, 1873a 12
          - *Corbula (Bothrocorbula) viminea* Guppy, 1866b 12
        - Subgenus *Caryocorbula* Gardner, 1926 14
          - *Corbula (Caryocorbula) dominicensis* Gabb, 1873b 14
          - *Corbula (Caryocorbula) sericea* Dall, 1898 15
        - Subgenus *Juliacorbula* Olsson and Harbison, 1953 17
          - *Corbula (Juliacorbula) fossilis* Pilsbry, 1922 17
        - Subgenus *Panamicorbula* Pilsbry, 1932 18
          - *Corbula (Panamicorbula) canae*, new species 19
          - *Corbula (Panamicorbula)* sp. 19
        - Subgenus *Varicorbula* Grant and Gale, 1931 20
          - *Corbula (Varicorbula) sanctidominici* Maury, 1925 20
- References Cited 22
- Appendix 1 26
- Appendix 2 26
- Plates 28
- Index 31

17. The families Cuspidariidae and Verticordiidae (Mollusca: Bivalvia)

Peter Jung

- Abstract 35
- Resumen 35
- Introduction 35
- Acknowledgments 35
- Biostratigraphy and Paleobiogeography 35
- Abbreviations of Repository Institutions 37
- Systematic Paleontology 39
  - Introduction 39
  - Systematics 39
  - Family Cuspidariidae 40
    - Genus *Cardiomya* A.Adams, 1864 40
      - Subgenus *Cardiomya* 40
        - *C. (C.) islahispaniolae* (Maury, 1917) 40
      - Subgenus *Bowdenia* Dall, 1903 42
        - *C. (B.) distira* (Dall, 1903) 42
    - Genus *Plectodon* Carpenter, 1864 44
      - *P. granulatus* (Dall, 1881) 44
  - Family Verticordiidae 45
    - Genus *Haliris* Dall, 1886 45
      - *H. jamaicensis* (Dall, 1903) 45
    - Genus *Trigonulina* d'Orbigny, 1842 46
      - *T. ornata* d'Orbigny, 1842 47
      - *T. pacifica*, new species 48
      - *T. bowdenensis* (Dall, 1903) 51
- References Cited 53
- Plates 55
- Index 74

LIST OF ILLUSTRATIONS AND TABLES

16. **The Family Corbulidae (Mollusca: Bivalvia)**

Laurie C. Anderson

Text-figure Page

1. Index map of areas investigated in the Cibao Valley, Dominican Republic 6
2. Part of the Río Cana section showing the stratigraphic distributions of *Corbula* species 7
3. Part of the Río Gurabo section showing the stratigraphic distributions of *Corbula* species 8
4. Plot of first and second principle component scores (PC1 and PC2) of right valves of *Corbula sericea* 9
5. Plot of PC1 and PC2 of right valves of *Corbula sericea* from shallow-marine deposits of the Río Cana and Río Mao sections 9
6. Plot of PC1 versus stratigraphic section (upper) and PC1 versus sediment type (lower) for *Corbula viminea* 10

Table

1. *Corbula viminea* valves from various sediment types for each stratigraphic section 11
2. Measurements of *Corbula* (*Caryocorbula*) *viminea* 13
3. Measurements of *Corbula* (*Caryocorbula*) *dominicensis* 15
4. Measurements of *Corbula* (*Caryocorbula*) *sericea* 16
5. Measurements of *Corbula* (*Juliacorbula*) *fossilis* 18
6. Measurements of *Corbula* (*Panamicorbula*) *canae* 19
7. Measurements of *Corbula* (*Panamicorbula*) sp. 20
8. Measurements of *Corbula* (*Varicorbula*) *sanctidominici* 21

17. **The Families Cuspidariidae and Verticordiidae (Mollusca: Bivavlia)**

Peter Jung

Text-figure

1. Index map showing location of investigated areas in the Cibao Valley, Dominican Republic 36
2. Columnar section of Río Gurabo showing occurrences of species dealt with herein 37
3. Río Gurabo: upper part of columnar section showing occurrences of species dealt with herein 37
4. Columnar section of Río Cana showing occurrences of species dealt with herein 38
5. Section exposed in Maury's Bluff 2 on Río Mao showing occurrence of *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917) and stratigraphic positions of NMB localities. 38
6. Section exposed at mouth of Arroyo Bajón on Río Mao showing occurrence of *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917) and stratigraphic positions of NMB localities 39
7. Section exposed at the downstream (eastern) end of Maury's Bluff 3 on Río Mao showing occurrence of *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917) and stratigraphic positions of NMB localities 39
8. Length/height diagram of *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917) 42
9. Length/height diagram of *Cardiomya* (*Bowdenia*) *distira* (Dall, 1903) 43
10. Length/height diagram of *Plectodon granulatus* (Dall, 1881) 45
11. Length/height diagram of *Haliris jamaicensis* (Dall, 1903) 46
12. Length/height diagram of *Trigonulina ornata* d'Orbigny, 1842 48
13. Histogram showing rib number distribution of *Trigonulina ornata* d'Orbigny 48
14. Length/height diagram of *Trigonulina pacifica,* new species 49
15. Histogram showing rib number distribution of *Trigonulina pacifica,* new species 49
16. Histogram showing rib number distribution of *Trigonulina bowdenensis* (Dall, 1903) 51
17. Length/height diagram of *Trigonulina bowdenensis* (Dall, 1903) 52

Table

1. Numbers of lots and specimens of each of the seven species of Cuspidariidae and Verticordiidae dealt with in this paper 40
2. Number of specimens available from the Neogene of the Dominican Republic and from the Bowden Formation of Jamaica 40
3. Diagnostic features of the three species of *Trigonulina* dealt with herein 50

NEOGENE PALEONTOLOGY IN THE NORTHERN DOMINICAN REPUBLIC 16. THE FAMILY CORBULIDAE (MOLLUSCA: BIVALVIA)

Laurie C. Anderson

Department of Geology and Geophysics, Louisiana State University,
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ABSTRACT

Corbulid bivalves (Myacea: Corbulidae) are an important constituent of fossiliferous Neogene sediments of the Cibao Valley, northern Dominican Republic. Six corbulid species referred to five subgenera within the genus *Corbula* are described and figured (*Bothrocorbula, Caryocorbula, Juliacorbula, Panamicorbula,* and *Varicorbula*). One species is new, *Corbula* (*Panamicorbula*) *canae*. This is the first description of a fossil *Panamicorbula* species and the first description of a *Panamicorbula* species outside of the eastern Pacific. The distribution of Dominican corbulids is strongly influenced by paleoenvironmental conditions such as salinity, depth, and bioclastic fabric. Corbulids are most common in Miocene sediments that were deposited predominantly in shallow-marine waters. *Corbula* (*Caryocorbula*) *sericea* Dall, 1898 has the widest stratigraphic and geographic distribution within the study area and is especially abundant in brackish-water and very shallow-marine deposits. *Corbula* (*Bothrocorbula*) *viminea* Guppy, 1866b is also common in shallow-marine and brackish-water deposits. *Corbula* (*Varicorbula*) *sanctidominici* Maury, 1925 occurs predominantly in shallow-marine sediments, whereas *Corbula* (*Panamicorbula*) *canae* n. sp. is restricted to brackish-water deposits of the Upper Miocene Cercado Formation in the Río Cana section. *Corbula* (*Caryocorbula*) *dominicensis* Gabb, 1873b and *Corbula* (*Juliacorbula*) *fossilis* Pilsbry, 1922 are rare. *Corbula dominicensis* is apparently restricted to the upper Lower to lower Middle Miocene Baitoa Formation of the Río Yaque del Norte section, and *C. fossilis* is found in Upper Miocene sediments of the Cercado and Gurabo Formations. Dominican corbulid species show close morphologic affinities to species of the Pliocene Bowden Formation of Jamaica, Neogene units of the Caribbean coast of Central America such as the Gatun Formation and sediments of the Limón Basin, Miocene and Pliocene deposits of Trinidad, and Miocene to Pleistocene sediments of Florida.

RESUMEN

Los bivalvos corbúlidos (Myacea: Corbulidae) constituyen una parte importante de los sedimentos fosilíferos del Neógeno en el Valle de Cibao al norte de la República Dominicana. A continuación, se describe y se dibuja seis especies pertenecientes a cinco subgéneros dentro del género *Corbula*, es decir, *Bothrocorbula, Caryocorbula, Juliacorbula, Panamicorbula,* y *Varicorbula*. *Corbula* (*Panamicorbula*) *canae* forma una nueva especie. Por primera vez se describe la especie fósil *Panamicorbula* y es la primera vez que se describe la especie *Panamicorbula* fuera del Pacífico este. La distribución de corbúlidos dominicanos está influenciada fuertemente por condiciones paleoambientales tales como la salinidad, profundidad de agua y fábrica bioclástica. Los corbúlidos se encuentran más comúnmente en aquellos sedimentos del Mioceno depositados predominantemente en aguas marinas someras. Dentro del la zona de estudio, *Corbula* (*Caryocorbula*) *sericea* Dall, 1898 muestra tener la distribución estratigráfica y geográfica más amplia y abunda sobre todo en agua salobre y en depósitos marinos de agua muy someras. *Corbula* (*Bothrocorbula*) *viminea* Guppy, 1866b también se encuentra comúnmente en depósitos marinos de agua somera y en depósitos de agua salobre. *Corbula* (*Varicorbula*) *sanctidominici* Maury, 1925 aparece en sedimentos marinos de poca profundidad mientras que *Corbula* (*Panamicorbula*) *canae*, n. sp. se encuentra restringida a depósitos de agua salobre en la formación Cercado del Mioceno superior en la sección del Río Cana. *Corbula* (*Caryocorbula*) *dominicensis* Gabb, 1873b y *Corbula* (*Juliacorbula*) *fossilis* Pilsbry, 1922 son poco frecuentes. Aparetmente, *C. dominicensis* queda restringida entre la parte superior del Mioceno inferior y la parte inferior del Mioceno intermedio de la formacio Baitoa en la sección del Río Yaque del Norte. *Corbula fossilis* se encuentra en los sedimentos de las formaciones Cercado y Gurabo con edad del Mioceno superior. Las especies de corbúlidos dominicanos muestran una afinidad morfológica a las especies de la formación Bowden del Plioceno en Jamaica, a las unidades Neógenas de la costa caribeña de centroamérica tales como la formación Gatun y los sedimentos de la cuenca Limón, a los depósitos de edad Miocena y Pliocena en Trinidad y a los sedimentos de Florida que comprenden desde el Mioceno hasta el Pleistoceno.

INTRODUCTION

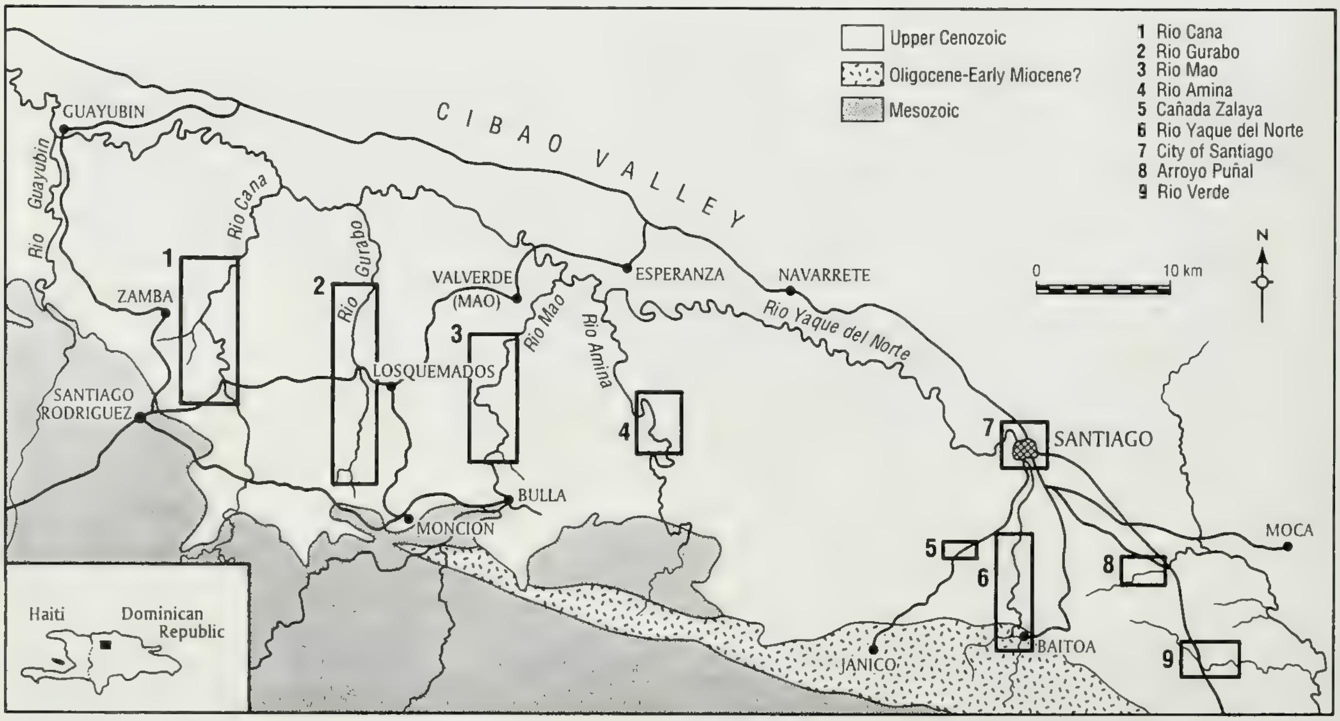
This work is one of a series of taxonomic monographs on Neogene fossils of the Cibao Valley in the northern Dominican Republic (Text-fig. 1). Saunders *et al.* (1986) provide detailed information on measured sections and samples, and a general biostratigraphic framework. The units studied include the upper Lower to lower Middle Miocene Baitoa, Upper Miocene Cercado, Upper Miocene to Lower Pliocene Gurabo, and Lower Pliocene Mao Formations. Although not highly diverse, corbulid bivalves occur throughout the stratigraphic section. They are most abundant, however, in brackish-water and shallow-marine sediments, which are typical of Miocene deposits in the study area.

ACKNOWLEDGMENTS

I am especially grateful for the generosity and assistance of Peter Jung, of the Naturhistorisches Museum Basel, Switzerland and Emily Vokes of Tulane University who provided long-term loans of extensive collections. A number of other institutions generously lent samples and specimens, and I would like to thank Warren Allmon of the Paleontological Research Institution; Thomas Waller, Warren Blow, and Jann Thompson of the United States National Museum of Natural History, Smithsonian Institution; Gary Rosenberg and Elana Benamy of the Academy of Natural Sciences of Philadelphia; Silvard Kool of the Museum of Comparative Zoology, Harvard University; Paul Taylor and Paul Jeffery of The Natural History Museum, London (British Museum, Natural History); and Klaus Westphal of the Museum of Geology, University of Wisconsin-Madison. Thanks also to Juan Lorenzo for translating the abstract, and to Emily Vokes, Jay Schneider, and John Kruger for reviewing the manuscript. This research was supported by the National Science Foundation (EAR-9316363), Sigma Xi, the Paleontological Society, and the Geological Society of America.

BIOSTRATIGRAPHY AND PALEOECOLOGY

Within the study area (Text-fig. 1), it is possible to trace changes in corbulid species distributions and intraspecific variability in a number of stratigraphic sections that record the interplay of paleoenvironment, time, and geography. Anderson (1994) documents in detail the relationship of corbulid species distributions and intraspecific variability to paleoenvironmental conditions in these sediments and those findings are reviewed here. Distributions of the most common species, *Corbula* (*Caryocorbula*) *sericea, Corbula* (*Bothrocorbula*) *viminea, Corbula* (*Varicorbula*) *sanctidominici,* and *Corbula* (*Panamicorbula*) *canae,* track paleoenvironmental conditions, and represent migrations into and out of the study area over time rather than speciation and extinction events (Anderson, 1994). Corbulid abundance and diversity reflect a preference for marginal-marine and shallow to intermediate marine habitats (< 100 m), which is compatible with habitat distributions of living corbulids. This correspondence of species distributions to paleoenvironmental conditions causes a temporal pattern in species distributions because paleoenvironmental conditions changed systematically through time in the study area (Saunders *et al.*, 1986). In the study area, corbulids are most abundant and diverse in Miocene marine sediments deposited primarily in shallow (approximately


Upper Cenozoic
Oligocene-Early Miocene?
Mesozoic
1 Rio Cana
2 Rio Gurabo
3 Rio Mao
4 Rio Amina
5 Cañada Zalaya
6 Rio Yaque del Norte
7 City of Santiago
8 Arroyo Puñal
9 Rio Verde
N
0
10 km
CIBAO VALLEY
GUAYUBIN
Rio Guayubin
Rio Cana
Rio Gurabo
ZAMBA
SANTIAGO RODRIGUEZ
VALVERDE (MAO)
Rio Mao
Rio Amina
LOSQUEMADOS
ESPERANZA
NAVARRETE
Rio Yaque del Norte
BULLA
MONCION
SANTIAGO
MOCA
JANICO
BAITOA
Haiti
Dominican Republic
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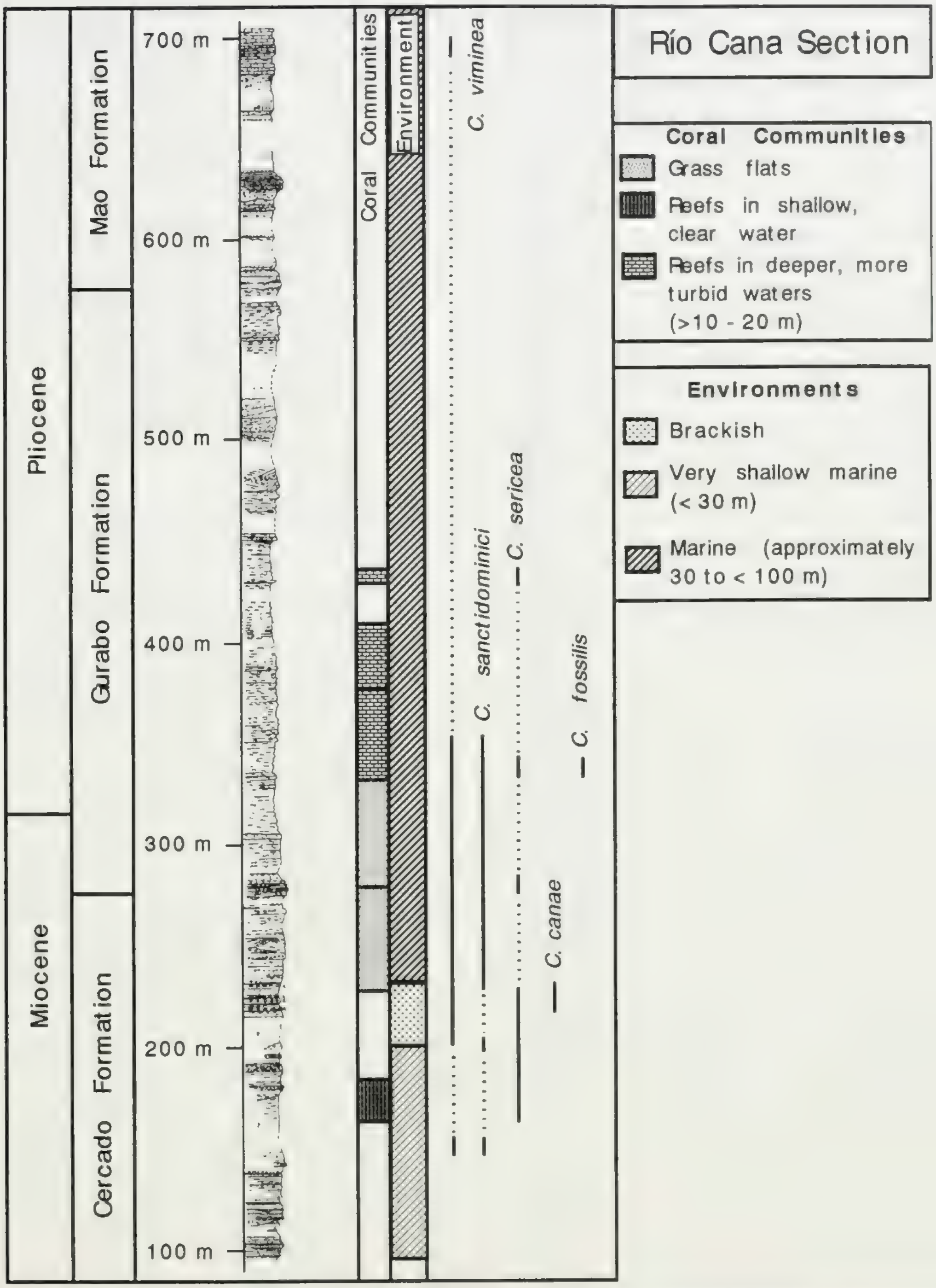
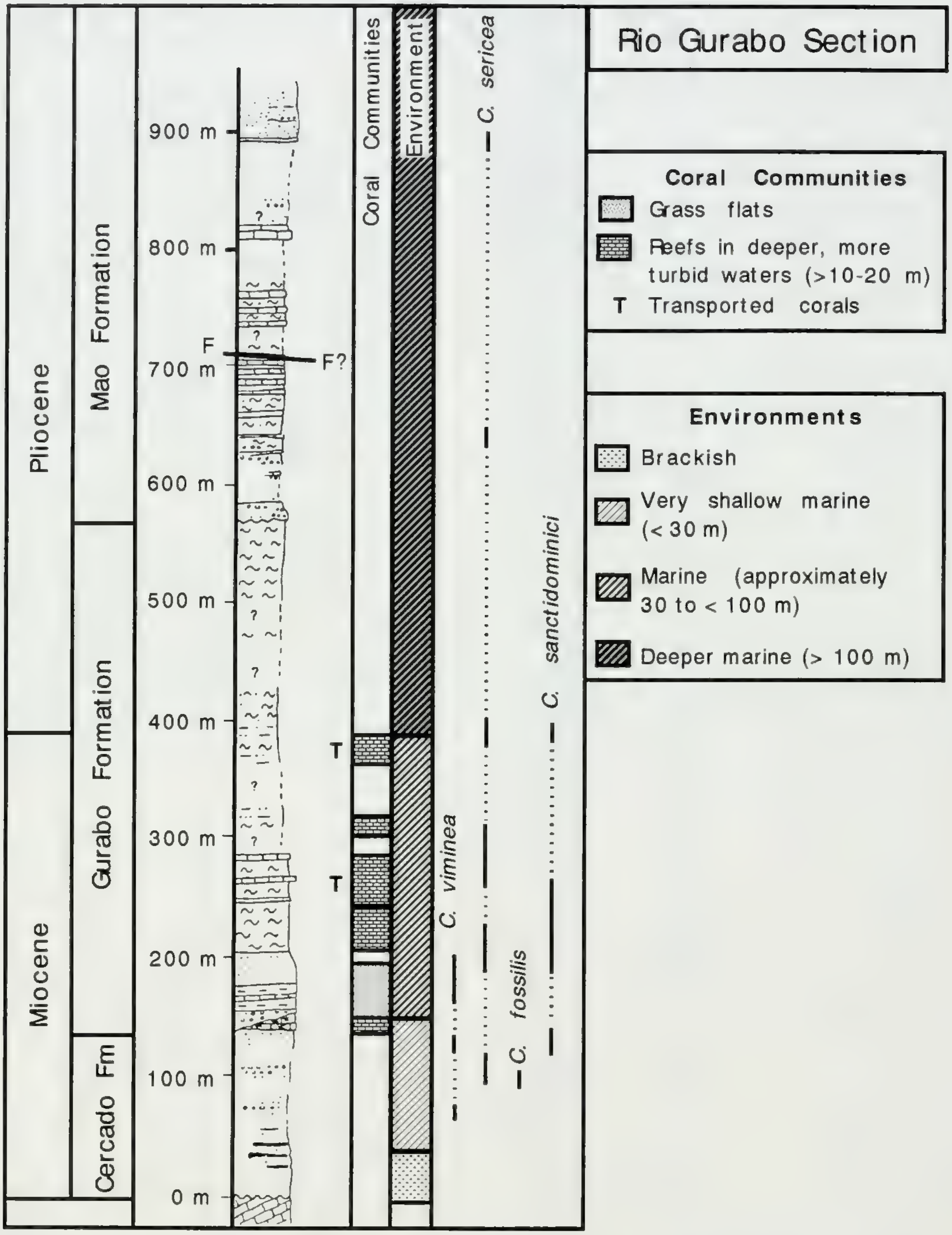
Text-figure 1.—Index map of areas investigated in the Cibao Valley, Dominican Republic (after Saunders et al., 1986).



Text-figure 2.—Part of the Río Cana section showing the stratigraphic distributions of *Corbula* species. Coral communities are based on average linkage cluster analysis of coral assemblages from Budd *et al.* (1996). Criteria used to distinguish environmental categories are outlined in Appendix 1.

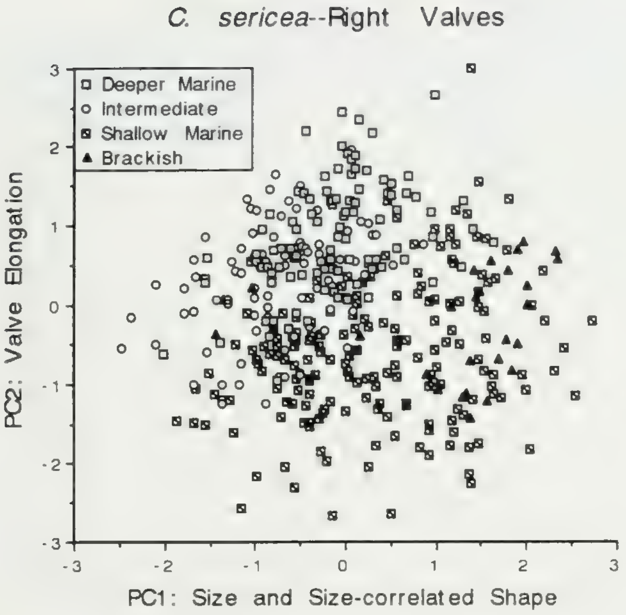
0–30 m) to intermediate depths (approximately 30–100 m), whereas corbulids are much less common and diverse in Pliocene sediments deposited in deeper marine (> 100 m) waters (Text-figs. 2, 3; see Appendix 1 for criteria used to construct these paleoenvironmental categories).

Slight differences in environmental preferences exist among Dominican Republic corbulid species. *Corbula sericea* is most abundant in brackish-water and shallow-marine to intermediate-marine deposits, although it is conspicuously absent from sediments deposited in grass-flat habitats such as the lower part of the Gurabo

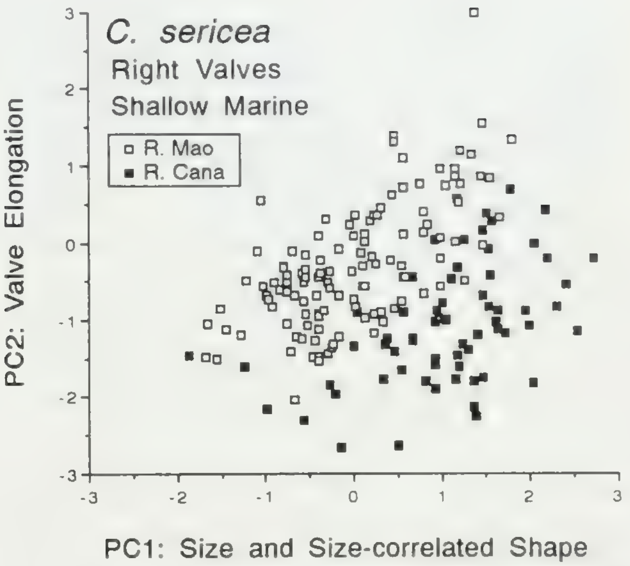


Text-figure 3.—Part of the Río Gurabo section showing the stratigraphic distributions of *Corbula* species. Coral communities are based on average linkage cluster analysis of coral assemblages from Budd *et al.* (1996). Criteria used to distinguish environmental categories are outlined in Appendix 1.

Formation in the Río Cana section (Text-fig. 2; Anderson, 1994). *Corbula viminea* also occurs in brackish-water and shallow-marine to intermediate-marine deposits in the study area, whereas *C. sanctidominici* occurs primarily in shallow- to intermediate-marine sediments (Text-figs. 2, 3). *Corbula canae* only occurs in brackish-water deposits of the Río Cana section, which were probably deposited in or near a mangrove swamp (Text-fig. 2; Anderson, 1994). *Corbula sericea* and *C. sanctidominici* also occur in deeper marine sediments



Text-figure 4.—Plot of first and second principle component scores (PC1 and PC2) of right valves of *Corbula sericea*. Procedures and results of the principal components analysis (PCA) are outlined in Anderson (1994). PC1 (explaining about 55 % of the variance) represents size and size-correlated shape variability. PC2 (explaining about 16 % of the variance) represents valve elongation, more elongate valves have negative principle component scores. Criteria used to distinguish environmental categories are outlined in Appendix 1. See Appendix 2 for samples used for each category.



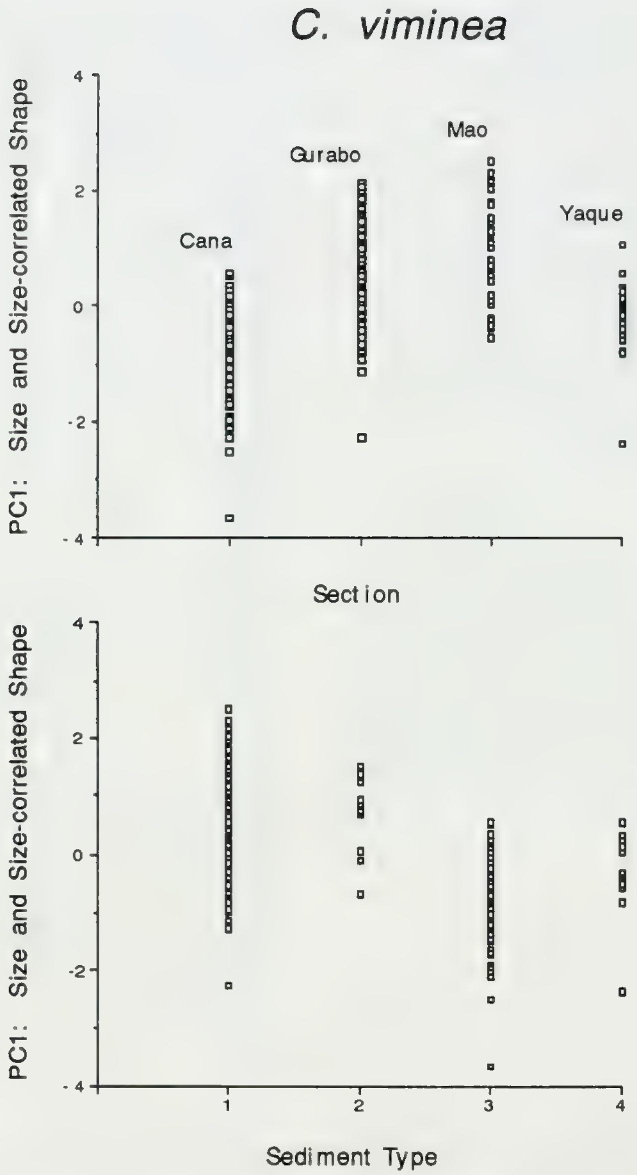
Text-figure 5.—Plot of PC1 and PC2 of right valves of *Corbula sericea* from shallow-marine deposits of the Río Cana and Río Mao sections, where this species is locally abundant. Size and shape differences are related to differences in bioclastic fabric. This plot shows a subset of data illustrated in Text-figure 4. See Appendix 2 for samples used for each category. (After Anderson, 1994.)

(>100 m deep) that show evidence of downslope movement, such as the top of the Río Gurabo section (Text-fig. 3), the top of the Río Yaque del Norte section, and in the Cañada Zalaya section (Saunders *et al.*, 1986; Anderson, 1994).

Intraspecific variability in the two most abundant corbulid species, *C. sericea* and *C. viminea,* are also related to paleoenvironmental factors. *Corbula sericea* shows continuous morphologic variability along a paleoenvironmental gradient of salinity, depth, and bioclastic fabric (Text-fig. 4). The smallest and least elongate *C. sericea* valves are found in intermediate and deeper marine deposits. Intermediate morphologies occur in shallow-marine deposits, and larger (but not more elongate) valves generally occur in brackish-water deposits. A few valves categorized as "brackish-water" from the López section of the Río Yaque del Norte, however, do not fit this trend (triangles with negative values on the first principle component axis [PC1 < 0] in Text-fig. 4). This anomaly is caused by difficulties in assigning these sediments to an environmental category because of conflicting environmental interpretations based on different faunal components. Even though the ostracode and foraminiferal faunas of the López section indicate deposition in brackish waters (Saunders *et al.*, 1986; Bold, 1988), these sediments also are rich in irregular echinoids and massive reef corals (Saunders *et al.*, 1986) indicating a significant marine influence. Alternatively, the other brackish-water valves are from sediments with an unambiguous brackish-water signal. These sediments of the Río Cana section are rich in brackish-water mollusks, including beds of *Anadara patricia* (Sowerby, 1850) (= "*Arca*" beds of Saunders *et al.*, 1986). This species is closely related to or is a subspecies of *Anadara grandis* (Broderip and Sowerby, 1829), a Recent species inhabiting intertidal mud banks bordering mangrove swamps in the eastern Pacific (Maury, 1922; Olsson, 1932, 1961; Woodring, 1973; Saunders *et al.*, 1986).

Geographic variation related to bioclastic fabric also can be discerned within *C. sericea* from roughly contemporaneous Miocene sediments of the Río Cana and Río Mao sections (Text-fig. 5; Anderson, 1994). *Corbula sericea* is larger and more elongate in the Río Cana section, where it occurs mainly in silts with bioclasts concentrated in lenses. In the Río Mao section, *C. sericea* is smaller and less elongate, and occurs in lenticular beds rich in bioclasts with a silty matrix.

Variation in *C. viminea* shows a morphologic cline from west to east in contemporaneous sediments, with variability related to sediment type and bioclastic fabric (Text-fig. 6; Table 1; Anderson, 1994). *Corbula viminea* is relatively small in the west (Río Cana section, where it occurs in pebbly shell beds), whereas to the



Text-figure 6.—Plot of PC1 versus stratigraphic section (upper) and PC1 versus sediment type (lower) for *Corbula viminea*. Procedures and results of PCA are outlined in Anderson (1994). PC1 (explaining about 46 % of the variance) represents size and size-correlated shape variability. Sediment types are: 1 = silts with bioclasts concentrated into lenticular beds or lenses, 2 = silts with bioclasts concentrated into burrows, 3 = silts with bioclasts scattered, and 4 = silty sands with bioclasts either scattered or concentrated. Two valves from the Río Yaque del Norte section are not included in the lower plot due to a lack of information on sediment type. Note clinal variation from west to east (Río Cana to Río Mao section). Geographic variation is apparently related to differences in sediment type among sections (see Table 1). See Appendix 2 for samples used for each category. (After Anderson, 1994.)

east (Río Gurabo and Río Mao sections, where it occurs in lenticular-, burrow-, or lens-shaped shell concentrations within silts) it becomes progressively larger. Valves from the Río Yaque del Norte section are from older deposits of the Baitoa Formation and do not follow this trend. Morphological differences among the four sediment-type/bioclastic-fabric categories are significant using the nonparametric Kruskal-Wallis analysis of variance ($H=103$, $df=3$, $p < 0.005$).

In summary, both abundance of particular corbulid species within their stratigraphic ranges and total ranges within stratigraphic sections are controlled by paleoenvironmental factors. In addition, intraspecific morphologic variability in *C. sericea* and *C. viminea* corresponds strongly with specific paleoenvironmental conditions. Although aspects of intraspecific variability in both species are related to bioclastic fabric, taphonomic processes do not control the morphologic variability observed (Anderson, 1994). Morphologic

Table 1.—*Corbula viminea* valves from various sediment types for each stratigraphic section. Sediment type categories are based on descriptions in Saunders *et al.* (1986) and on personal observation. Categories are: 1) silts with bioclasts in lenticular beds or lenses, 2) silts with bioclasts filling burrows, 3) silts with mollusks dispersed in matrix, 4) silty sands with bioclasts dispersed or concentrated. Samples used are listed in Appendix 2.

	sediment type			
section	*1*	*2*	*3*	*4*
Cana	14	0	98	0
Gurabo	88	11	0	0
Mao	44	0	0	0
Yaque[1]	0	0	8	15

[1] Two valves from this section were not included in the analysis because sediment type was unknown.

change within these species over time is relatively minor or is a side effect of systematic changes in environmental conditions.

BIOGEOGRAPHY

In tropical America (including the Caribbean Sea, eastern Pacific Ocean, and western Atlantic Ocean), Miocene to Recent corbulid faunas are nearly identical at the subgenus level, except for a few apparently endemic, low-diversity taxa. Widespread and abundant subgenera include *Varicorbula* Grant and Gale, 1931 (*Notocorbula* Iredale, 1930 of some authors) and *Caryocorbula* Gardner, 1926, and to a lesser extent *Bothrocorbula* Gabb, 1873a and *Juliacorbula* Olsson and Harbison, 1953. Endemic subgenera typically inhabit the Recent Panamic-Pacific province and include *Serracorbula* Olsson, 1961 and *Tenuicorbula* Olsson, 1932 (also found in the Tertiary of Peru, Venezuela, and Trinidad). *Panamicorbula* Pilsbry, 1932 was first described from the Recent Panamic-Pacific province, but also is reported from the Miocene of the Pacific coast of Costa Rica (Punta Judas; Seyfried *et al.*, 1985), the Miocene Cercado Formation of the Dominican Republic (Anderson, 1991, 1994), and the Pliocene l'Enfer and Springvale Formations of Trinidad (see p. 19).

Dominican corbulid species show affinities to a number of other Miocene to Pleistocene faunas. The Pliocene Bowden Formation of Jamaica shares two species with the Dominican fauna, *Corbula viminea* and *C. sericea,* and contains a species of *Varicorbula, Corbula* (*Varicorbula*) *heterogena* Guppy (in Dall, 1898), that is morphologically very similar to *C. sanctidominici. Corbula viminea* and *C. sericea* also are reported from Neogene deposits of the Limón Basin, Costa Rica (Dall, 1898; Olsson, 1922). In addition, the following units all contain a number of corbulid species with strong affinities to Dominican corbulids: Miocene and Pliocene sediments of Trinidad (including the Manzanilla, Springvale, l'Enfer Formations; Maury, 1925; Jung, 1969), the Miocene Gatun Formation of Panama (Woodring, 1982), Upper Miocene Santa Rosa beds of Veracruz, Mexico (Perrilliat [1984], who assigns these beds to the Agueguexquite Formation; E. Vokes [1989] states, however, that this formation only occurs farther north, near Coatzacoalcos, and is Pliocene), and Miocene to Pleistocene sediments of Florida (Dall, 1898; Gardner, 1928; Olsson and Harbison, 1953).

ABBREVIATIONS OF REPOSITORY INSTITUTIONS

The following abbreviations for repository institutions are used in this paper:

ANSP:	Academy of Natural Sciences, Philadelphia, PA, U.S.A.
IGM:	Instituto de Geología, Ciudad Universitaria de México, D.F., México
BMNH:	The Natural History Museum, London, England, U.K. (British Museum, Natural History)
NMB:	Naturhistorisches Museum Basel, Switzerland
PRI:	Paleontological Research Institution, Ithaca, NY, U.S.A.
TU:	Tulane University, New Orleans, LA, U.S.A.
USNM:	United States National Museum of Natural History, Washington, DC, U.S.A.
UW:	Museum of Geology, University of Wisconsin-Madison, Madison, WI, U.S.A.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

All species described here are assigned to the genus *Corbula*; other supraspecific taxa are considered subgenera, following Vaught (1989). All subgenera share the same basic hinge structure and differ primarily in shape, ornamentation, and the degree of disparity in size, shape, and ornamentation of the left and right valves. A majority of species described here are abundant enough to incorporate intraspecific variation into interpretations of species boundaries (see also Anderson, 1991, 1994 for quantitative treatments). Variability is considered intraspecific if it can be related to size differences (presumably ontogenetic) and/or to changes in paleoenvironmental conditions. In comparison to this approach, the taxonomy of living corbulids has been more typological because taxonomic and systematic studies have not incorporated potential phenotypic variation caused by ontogenetic, environmental, or geographic factors.

Only forms considered identical to described species are listed in the synonymy. A question mark (?) before an item in a synonymy indicates that material was insufficient to confirm conspecific status. The abbreviation "sp." indicates that the described species could be identified to the subgenus but not to the specific level. *Diagnoses* are used both for species and for supraspecific categories and indicate the diagnostic features of a particular taxon. *Descriptions* are used for species only, and outline overall species morphology. The *Remarks* section provides information on the particular taxon described, and may include a taxonomic discussion, taphonomic and paleoenvironmental information, and geologic and geographic ranges (ranges for supraspecific taxa only). The *Comparisons* section outlines differences between the species being described and morphologically similar species. Detailed locality information for Dominican Republic samples is listed in the *Occurrence* section, whereas the *Distribution* section is a more general statement of a species' geographic and stratigraphic distribution inside and outside the Dominican Republic. A question mark (?) after a formation indicates that synonymy is uncertain.

SYSTEMATICS

Family **CORBULIDAE** Lamarck, 1818

Diagnosis.—Small- to moderate-sized sturdy shells (length typically 2 cm or less), inequilateral, and generally strongly inflated. Slightly to strongly inequivalved in size and shape; left valves smaller than right valves. Hinge simple with anterior cardinal tooth in right valve and socket in left valve. Resilifer present behind hinge; typically a projecting chondrophore in left valve that corresponds to socket-like resilifer in right valve. Pallial sinus small to obsolete. (See H. Vokes, 1945; Moore, 1969.)

Subfamily **CORBULINAE** Lamarck, 1818

Diagnosis.—Left valve typically slightly smaller than right valve. Chondrophore in left valve present in most species, fitting into socket-like resilifer in right valve. Posterior typically rostrate. (See H. Vokes, 1945; Moore, 1969.)

Genus **CORBULA** Bruguière, 1797

Corbula Bruguière, 1797, pl. 230.
Corbula Lamarck, 1799, p. 89.
Aloidis Megerle von Mühlfeldt, 1811, p. 67.

Type species.—Corbula sulcata Lamarck, 1801; by subsequent designation, Schmidt (1818); Recent, Senegal.

Diagnosis.—Shell sturdy, moderately inflated, inequilateral and inequivalved; left valve smaller. Shells smooth to concentrically ribbed. Hinge with cardinal tooth in right valve and cardinal socket in left valve. In type species, socket-like resilifer present behind dentition in both valves; in most species, however, left valve with chondrophore and right valve with socket-like resilifer. (See H. Vokes, 1945.)

Remarks.—The generic name *Corbula* was first used in Bruguière (1797) in a plate title, and the name is generally credited to him, although he did not describe the genus. Lamarck (1799) first described *Corbula* but did not specify a type. Schmidt (1818) subsequently designated *Corbula sulcata* as type (see Stewart, 1930). *Aloidis* Megerle von Mühlfeldt (1811) is a synonym of *Corbula* (H. Vokes, 1945, 1980). Unlike most other members of the genus, the type species, *Corbula* (*Corbula*) *sulcata,* has no chondrophore in the left valve; the resilium instead is received in a socket-like resilifer behind the cardinal socket.

Geologic range of the genus is Cretaceous to Recent (Moore, 1969). The genus is found worldwide in tropical to temperate waters that range from marine to brackish salinities (Boss, 1982). Some species are tolerant of waters low in dissolved oxygen (Lewy and Samtleben, 1979).

Subgenus **BOTHROCORBULA** Gabb, 1873a

Bothrocorbula Gabb, 1873a, p. 274, pl. 10, figs. 3, 3a.

Type species.—Corbula viminea Guppy, 1866b; by monotypy. Pliocene, Bowden Formation, Jamaica.

Diagnosis.—Shell moderately large and thickened. Valves subequal, with coarse concentric ribs and fine radial striations. Characteristic deep lunular depression in front of umbos. Right valve hinge with cardinal tooth in front of socket-like resilifer. Left valve hinge with cardinal socket in front of chondrophore. (See Gabb, 1873a; Gardner, 1926; H. Vokes, 1945.)

Remarks.—This subgenus ranges from Miocene to Pleistocene in Florida, the West Indies, and eastern Central America (see p. 13–14). It is found in sediments deposited in shallow-marine and marginal-marine waters. The Miocene-to-Recent taxon *Hexacorbula* Olsson, 1932 closely resembles *Bothrocorbula* but lacks a lunular pit.

Corbula (Bothrocorbula) viminea Guppy, 1866b
Plate 1, figures 1–8, 10, 11, 13, 14

Corbula viminea Guppy, 1866b, p. 293, pl. 18, fig. 11; Olsson, 1922, p. 270, pl. 28, fig. 25.
Corbula (*Bothrocorbula*) *viminea* Guppy. Maury, 1917, p. 233–234, pl. 39, figs. 20, 21; 1925, p. 108–109, pl. 19, fig. 19; Pilsbry, 1922, p. 428; Woodring, 1925, p. 189–190, pl. 26, figs. 5–8; Ramírez, 1950, p. 38–39, pl. 7, fig. 9; Anderson, 1994, figs. 2.1–2.4.

Diagnosis.—Species characterized by relatively large size, prominent lunule, thick valves, coarse concentric ribs, fine radial striations, evenly rounded anterior margin, and evenly rounded to slightly sinuous ventral margin.

Description.—Valves moderately large, subequal in size and shape. Right valve slightly larger than left, only overlapping left ventrally. Valve thickness widely variable, although variability in part preservational because valve inner layers tend to slough off. Valves elongate-ovate with rostrum and arcuate keel. On some valves, posterior slope has midline depression parallel to keel. Continuous variation seen in expression of rostrum and ventral margin, ranging from subdued rostrum and evenly rounded ventral margin, to short posteriorly-pointing rostrum and evenly rounded ventral margin, to short ventrally-pointing rostrum and gently sinuous ventral margin (concave just anterior of rostrum). Valve ornamented with coarse concentric ribs that die out before reaching keel. Fine concentric and radial striations superimposed on coarse ribs, and especially visible between ribs. Posterior slope and nepionic shell with fine concentric striations, but lacking radial and coarse concentric ribs.

Both valves with deep lunule anterior of umbo. Lunule larger and deeper in left valve, encompassing entire hinge plate. Right valve hinge with large, triangular, hooked-shaped, cardinal tooth and posterior socket-like, broadly-open resilifer. Broad short ridge descends from resilifer roof and extends across part of hinge plate. Hinge plate surface depressed at resilifer. Left valve hinge with deep, triangular, hook-shaped anterior socket and broad posterior chondrophore. Hinge plate strongly sinuous resulting in obliquely-oriented cardinal socket. Dorsal surface of chondrophore with anterior and posterior ridges separated by midline trough. Posterior ridge more prominent and with denticle. Adductor muscle scars relatively large and thickened; posterior scar circular, anterior scar ovate. Pallial sinus obsolete.

Type Material.—Syntypes: BMNH 64088 (left valve), BMNH 64099 (right valve). Right valve figured by Guppy (1866b, Pl. 18, fig. 11) Both valves are figured here (Pl. 1, figs. 3, 6).

Type locality.—"Miocene" (= Bowden Formation, Pliocene), Jamaica. The type locality is here restricted to TU 705: type locality of Bowden Formation (Pliocene), Bowden, Parish of St. Thomas, Jamaica (fide H. Vokes, 1989).

Material.—Measured and/or figured specimens: NMB G 14103, 14104, 14105, 14106, 14107, 14108, 14109, 14110. Other specimens (over 600 valves) are cataloged by locality, which are listed in the Occurrence section.

Table 2.—Measurements of *Corbula (Bothrocorbula) viminea.* Figures are in mm.

	valve	*length*	*height*	*width*
BMNH 64088: syntype (Pl. 1, fig. 3)	right	19.1	13.9	6.3
BMNH 64099: syntype (Pl. 1, fig. 6)	left	15.1	10.3	5.0
USNM 115648: (figured by Woodring, 1925)	right	17.5	12.0	4.8
PRI 919: (figured by Maury, 1917)	left	14.0	9.6	4.1
PRI 919: (figured by Maury, 1917)	right	15.5	10.6	4.8
NMB G 14103: (Pl. 1, fig. 14); NMB locality 16923	left	15.9	11.8	4.9
NMB G 14104: (Pl. 1, fig. 13); NMB locality 16923	right	17.4	12.3	6.0
NMB G 14105: (Pl. 1, fig. 11); NMB locality 15900	left	15.3	11.3	5.4
NMB G 14106: (Pl. 1, fig. 10); NMB locality 15900	right	16.3	11.5	6.0
NMB G 14107: (Pl. 1, fig. 8); TU locality 1230	left	14.1	9.7	5.0
NMB G 14108: (Pl. 1, fig. 7); TU locality 1230	right	14.2	9.9	5.2
NMB G 14109: (Pl. 1, figs. 2, 5); TU locality 1364	left	13.3	9.3	3.8
NMB G 14110: (Pl. 1, figs. 1, 4); TU locality 1364	right	14.0	9.7	4.8

Remarks.—This is a common species in upper Miocene shallow-marine and brackish-water deposits of the Río Cana, Río Gurabo, Río Mao, Río Yaque del Norte, and Río Amina sections. It is typically found in silty shell beds or thin shell-rich stringers interbedded with silts. This species also is found in bioclast-rich sediment filling burrows, scattered in silts, and in pebbly and conglomeratic layers. Woodring (1925) states that Dominican forms of *C. viminea* are smaller and slightly more elongate than Jamaican forms.

Comparison.—*Corbula* (*Bothrocorbula*) *wilcoxii* Dall, 1898, a Pleistocene species from the Caloosahatchee and Bermont formations of southern Florida (Anderson, unpublished data), shows some morphologic overlap with *C. viminea. Corbula viminea* tends to be slightly larger and has a more evenly rounded anterior margin than *C. wilcoxii.* The valve margin of *C. wilcoxii* typically is flattened into a short horizontal ledge anterior of the beak, resulting in a projecting anterior. Although the two species typically are distinct, intermediate forms can be found in both species.

Corbula (*Bothrocorbula*) *synarmostes* Dall, 1898 of the Miocene Chipola Formation of Florida is smaller and has a much smaller lunule than *C. viminea. Corbula* (*Bothrocorbula*) *radiatula* Dall, 1898 of the Miocene Oak Grove Formation of Florida is also smaller than *C. viminea,* has a reduced lunule, and more pronounced radial ornament.

Occurrence.—This species was collected from the following areas (see Saunders et al., 1986 for locality information):

Río Cana: Cercado Formation: TU 1230, and NMB 16835, 16836, 16837, 16838, 16839, 16844, 16857, 16988, 16989, 16993, 17005. Lower Gurabo Formation: NMB 16831, 16832, 16833, 16820. Upper Gurabo Formation: TU 1354, and NMB 16817–16819, 16824. Mao Formation (Mao Adentro Limestone Member): NMB 16873.

Río Gurabo: Cercado Formation: TU 1359, 1373, 1377, 1419, and NMB 15896, 15900, 15901, 15903, 15904, 15906, 15907, 15908, 15910. Lower Gurabo Formation: TU 1297, 1298, and NMB 15876, 15878, 15882, 15887.

Río Mao: Cercado Formation: TU 1294, and NMB 16913 (all correspond to Maury's Bluff 3); NMB 16915, 16917, 16918, 16923, 16924, 16926, 16927, 16928 (all Arroyo Bajón); NMB 16914, 16930, 16932 (all Maury's Bluff 2).

Río Amina: Gurabo Formation: TU 1412.

Río Yaque del Norte: Baitoa Formation: TU 1226, 1363, 1364, and NMB 16935, 16936, 16938, 17286, 17288, 17289 (all López section). Unnamed formation: TU 1445 (Angostura).

Distribution.—Upper Lower to lower Middle Miocene Baitoa, Upper Miocene Cercado, Upper Miocene to Lower Pliocene Gurabo, and Lower Pliocene Mao Formations, Dominican Republic; Miocene Thomonde and Las Canobas Formations (?), Haiti (see Guppy, 1876; Woodring et al., 1924; Woodring, 1925); Pliocene Bowden Formation, Jamaica; Pliocene Río Banano Formation, Costa Rica.

Subgenus **CARYOCORBULA** Gardner, 1926

Caryocorbula Gardner, 1926, p. 46.

Type species.—Corbula alabamiensis Lea, 1833, by original designation. Middle Eocene (Claibornian Stage) of Alabama.

Diagnosis.—Small- to moderately-sized, moderately thickened valves. Left valve slightly smaller than right. Shells typically elongate, with posterior keel and rostrum. Valves with moderately coarse concentric ribs; some also with fine radial striations. Right valve hinge with anterior cardinal tooth and posterior socket-like resilifer. Left valve hinge with anterior cardinal socket and posterior chondrophore. (See Gardner, 1926.)

Remarks.—Caryocorbula includes most American species assigned to *Cuneocorbula* Cossmann, 1886 by a number of authors (*e.g.*, Dall, 1898; Maury, 1917). Its geologic range is Eocene to Recent in North and South America and East Asia (Moore, 1969). *Caryocorbula* species inhabit shallow-marine to marginal-marine environments.

Corbula (Caryocorbula) dominicensis Gabb, 1873b

Plate 1, figures 9, 12; Plate 2, figures 1, 2, 4, 5

Corbula dominicensis Gabb, 1873b, p. 247; Pilsbry, 1922, p. 427, pl. 46, figs. 12, 13.

?*Corbula* (*Cuneocorbula*) *dominicensis* Gabb. Maury, 1917, p. 232, pl. 39, figs. 14, 15.

Diagnosis.—Species characterized by elongate shape and sculpture of concentric, closely-spaced, moderately coarse ribs and no radial striations. Also distinguished from other Dominican corbulids by relatively uninflated valves, moderately thickened shell, and large size.

Description.—Right and left valves subequal in size and shape; right valve slightly larger than left. Umbos slightly anterior of valve midline. Greatest convexity of ventral margin anterior of umbo in left valve but even with or anterior of umbo in right valve. Valves not strongly inflated and shells not greatly thickened. Sculpture consists of concentric, closely-spaced, flat-topped ribs with steep dorsal and more gradual ventral slopes. Ribs do not split and double towards posterior keel as described by Pilsbry (1922). Radial sculpture absent. Nepionic shell somewhat distinct, with very fine concentric ribs. Posterior region of valve with sharp arcuate keel and small rostrum. Left valve hinge with anterior, large, triangular socket that opens ventrally. Broad chondrophore posterior of cardinal socket, continuous with dorsal margin, and with midline cleft. Right valve hinge with anterior, large, hook-shaped, triangular cardinal tooth. Widely open socket-like resilifer present posterior of cardinal tooth. Long furrows for reception of left valve located anterior and posterior of, and continuous with, right valve hinge. Adductor muscle scars large and thickened; posterior scar circular, anterior scar ovate. Very small pallial sinus present.

Type Material.—Lectotype: ANSP 2691 (articulated shell). Specimens figured by Pilsbry (1922, p. 427, pl. 46, figs. 12, 13), who designated the lectotype, which is now lost (G. Rosenberg, pers. comm., 1993).

Type locality.—None designated. It is here designated as NMB 17281: Baitoa Formation (upper Lower to lower Middle Miocene), López section, Río Yaque del Norte, Dominican Republic.

Material.—Measured and/or figured specimens: NMB G 14111, 14112, 14113. Other specimens (four right valves, two left valves, three articulated shells, one internal mold, and two left valve fragments) are cataloged by locality, which are listed in the Occurrence section.

Table 3.—Measurements of *Corbula* (*Caryocorbula*) *dominicensis*. Figures are in mm.

specimen	*valve*	*length*	*height*	*width*
ANSP 2691: lectotype (figured by Pilsbry, 1922)	articulated	14.6	9.0	6.0[1]
PRI 29033: (figured by Maury, 1917; refigured in Pl. 2, fig. 3)	left	13.4	8.6	3.3
PRI 29033: (figured by Maury, 1917; refigured in Pl. 2, fig. 6)	right	12.6	8.6	3.2
NMB G 14112: (Pl. 2, figs. 2, 5); TU locality 1226	left	13.6	8.2	3.1
NMB G 14113: (Pl. 2, figs. 1, 4); TU locality 1226	right	14.2	9.0	4.0
NMB G 14111: (Pl. 1, figs. 9, 12); NMB locality 17281	articulated	15.3	9.2	6.9[1]

[1] diameter of articulated shell.

Measurements.—See Table 3.

Remarks.—This is a rare species found in conglomerates or conglomeratic lenses containing mollusks. In this study, it was found only in the upper Lower to lower Middle Miocene Baitoa Formation of the Río Yaque del Norte section (see Saunders *et al.*, 1986). Maury (1917), however, reports *C. dominicensis* from the upper Miocene Cercado Formation of the Río Cana Section (Zone H of the Río Cana at Caimito; equivalent to TU 1230 [Saunders *et al.*, 1986; H. Vokes, 1989]). Maury's specimens (refigured in Pl. 2, figs. 3, 5) differ from the Baitoa Formation specimens in several ways. Maury's specimens are smaller, less elongate, have a more centrally located umbo, more strongly arcuate keel, larger posterior slope, and coarser concentric ribs. Smaller specimens from the Baitoa Formation closely resemble Maury's specimens, but with the limited material available, it was not possible to unite or separate the specimens from the two formations.

Comparison.—*Corbula* (*Caryocorbula*) *democracia* F. Hodson, in Hodson and Hodson, 1931, from the Miocene of Falcón, Venezuela is much larger (holotype length is 22.5 mm), is less elongate, has a more convex ventral margin, and has coarser concentric ribs than *C. dominicensis*. *Corbula* (*Caryocorbula*) *prenasuta* Olsson, 1964 of the lower and middle Gatun Formation (Upper Miocene) of Panama and the Upper Miocene Angostura Formation of Ecuador is about the same size as *C. dominicensis* but is more strongly rostrate with the rostrum located in a more dorsal position on the posterior margin, and has a more strongly arcuate keel, giving the rostrum a twisted appearance. *Corbula* (*Caryocorbula*) *dominicensis veracruzana* Perrilliat, 1984 from the Upper Miocene Santa Rosa beds, Veracruz, Mexico more closely resembles *C. democracia* than *C. dominicensis* s. s., and probably is not a subspecies of *C. dominicensis*.

Occurrence.—This species was collected from the following areas (see Saunders *et al.*, 1986 for locality information):

Río Yaque del Norte: Baitoa Formation: TU 1226, and NMB 17281, 17283.

Distribution.—Upper Lower to lower Middle Miocene Baitoa, Upper Miocene Cercado (?) Formations, Dominican Republic.

Corbula (Caryocorbula) sericea Dall, 1898
Plate 2, figures 7–21

Corbula lavaleana Orbigny. Gabb, 1873b, p. 247; 1881, p. 371.

Corbula (*Corbula*) *sericea* Dall, 1898, p. 848–849; 1900, pl. 36, fig. 8; Woodring, 1925, p. 186–187, pl. 25, figs 19–22.

Corbula (*Cuneocorbula*) *cercadica* Maury, 1917, p. 232–233, pl. 39, figs. 16, 17.

Corbula (*Cuneocorbula*) *caimitica* Maury, 1917, p. 233, pl. 39, figs. 18, 19.

Corbula sericea Dall. Pilsbry, 1922, p. 427.

Corbula (*Caryocorbula*) *cercadica* Maury. Anderson, 1994, figs. 1.1–1.5.

Diagnosis.—Species characterized by small, inflated, elongate-ovate to subtriangular valves with relatively fine, closely and evenly spaced concentric ribs, and very fine radial striations.

Description.—Shells small to moderately sized; moderately inflated. Valves thin to relatively thick, variability in part preservational. Left and right valves subequal in size and shape; right valve larger and slightly less elongate than left. Umbo at or slightly anterior of valve midline. Keel nearly straight to arcuate. Valve shape varies from triangular to elongate ovate; elongate valves more rostrate. Ornament of closely spaced concentric ribs. Fine radial ribs present but variably expressed. Radial striations present, beaded under magnification.

Right valve hinge with anterior, large, triangular, hook-shaped, cardinal tooth, and posterior, large, widely open, socket-like resilifer. Ridge bisects roof of resilifer, as in *C. viminea*. Long furrow present on either side of right valve hinge for reception of left valve's thickened dorsal margin. Posterior furrow continuous with resilifer. Left valve hinge with anterior, large, triangular, cardinal socket and broad posterior chondrophore. Anterior half of chondrophore's dorsal surface concave, posterior half convex. Small denticle present at posterior edge of chondrophore. Adductor muscle scars slightly thickened. Posterior scar circular; anterior scar ovate. Pallial sinus small to obsolete.

Type Material.—Lectotype: USNM 135655 (right valve). Lectotype designated by Woodring (1925). Specimen figured by Dall (1900, Pl. 36, fig. 8) and Woodring (1925, Pl. 25, figs. 19, 20), and refigured here (Pl. 2, fig. 7).

Type locality.—USGS locality 2692: track ballast

Table 4.—Measurements of *Corbula* (*Caryocorbula*) *sericea.* Figures are in mm.

specimen	*valve*	*length*	*height*	*width*
USNM 135655: lectotype (Pl. 2, fig. 7)	right	5.3	4.0	2.0
PRI 29035[1]: (figured by Maury, 1917; refigured in Pl. 2, fig. 9)	left	5.6	3.9	2.0
PRI 29035[1]: (figured by Maury, 1917; refigured in Pl. 2, fig. 8)	right	6.6	4.6	2.3
NMB G 14114: (Pl. 2, fig. 17); NMB locality 16928	left	5.6	4.0	1.8
NMB G 14115: (Pl. 2, fig. 16); NMB locality 16928	right	6.1	4.5	2.1
NMB G 14116: (Pl. 2, fig. 19); NMB locality 15869	left	4.2	2.9	1.4
NMB G 14117: (Pl. 2, fig. 18); NMB locality 15869	right	4.9	3.2	1.6
NMB G 14118: (Pl. 2, figs. 11, 15); NMB locality 16848	left	7.5	4.7	2.4
NMB G 14119: (Pl. 2, figs. 10, 14); NMB locality 16848	right	7.0	5.0	3.0
NMB G 14120: (Pl. 2, fig. 13); NMB locality 16855	left	7.1	4.6	2.3
NMB G 14121: (Pl. 2, fig. 12); NMB locality 16855	right	8.1	4.8	2.7
NMB G 14122: (Pl. 2, fig. 21); TU locality 1227A	left	5.6	3.9	2.0
NMB G 14123: (Pl. 2, fig. 20); TU locality 1227A	right	6.0	4.2	2.3

[1] Mislabeled as cotypes (syntypes) of *Corbula* (*Cuneocorbula*) *caimitica* but are *Corbula* (*Cuneocorbula*) *cercadica* illustrated in pl. 39, figs. 16, 17 of Maury 1917). The syntypes of *Corbula* (*Cuneocorbula*) *caimitica* are apparently lost (W. Allmon, pers. comm., 1994).

for railroad 1.5 miles west of Limón, Costa Rica. The source of the aggregate is USGS locality 2694: *in situ* Limón Reef (= Moín Formation, Pliocene).

Material.—Measured and/or figured specimens: NMB G 14114, 14115, 14116, 14117, 14118, 14119, 14120, 14121, 14122, 14123. Additional material: UW 1863/25, 1863/26. Other specimens (thousands of valves) are cataloged by locality, which are listed in the Occurrence section.

Measurements.—See Table 4.

Remarks.—This species is locally abundant in Upper Miocene shallow-marine (< 30 m) and brackish-water deposits of the Río Cana, Río Gurabo and Río Mao sections. It also occurs in Miocene and Pliocene intermediate and deeper marine (> 30 to + 100 m) sediments of the Río Cana, Río Gurabo, Cañada Zalaya, Río Amina, Río Verde, and Río Yaque del Norte sections. *Corbula sericea* is found in a variety of sediment types in the study area although it predominantly occurs scattered in silts and in shell beds with a silty matrix.

Corbula sericea is morphologically variable, although most shape variation is highly correlated with size. Size and size-correlated shape, in turn, are continuous and are closely related to paleoenvironmental conditions (Anderson, 1994). Specimens from very shallow marine deposits of the Río Mao have a subtriangular valve outline (Pl. 2, figs. 16, 17). Average height to length ratio (H:L) is 0.72 (all height to length ratios for *C. sericea* reported here are based on data from Anderson, 1994). The ventral margin of these forms is directed upward at a slight angle in both directions from the midline. There is no invagination of the ventral margin in association with the keel or rostrum. The rostrum is very subdued to nearly absent and is directed downward. Most forms have an evenly rounded dorsal margin, although in some, the umbo is somewhat set off and projecting.

Specimens from very shallow marine sediments of the Río Cana section (Pl. 2, figs. 12, 13) tend to be larger and more elongate (average H:L = 0.63) than those of the Río Mao section. In addition, the rostrum in Río Cana specimens is located in a more dorsal position on the posterior margin, and it tends to point posteriorly rather than ventrally. As a result, valves have an ovate outline. Convexity of the keel varies, but most specimens have a slightly sinuous keel. The dorsoanterior slope is nearly straight, and the highest point of the valve is located more anteriorly than in the Río Mao specimens.

Brackish water forms from the Río Cana section (Pl. 2, figs. 10, 11, 14, 15) also are large, ovate, and elongate (average H:L = 0.68), although not as elongate as valves from very shallow-marine deposits of the Río Cana. In addition, the dorsoanterior slope is more rounded than in very shallow-marine forms. The rostrum is moderately expressed to obsolete, and when present, is directed ventrally. The ventral margin is strongly rounded, and the keel less sinuous than in shallow-marine forms of the Río Cana section.

Valves from intermediate and deeper marine deposits of the Río Gurabo, Río Mao, Río Cana, and Río Yaque del Norte sections tend to be smaller than those of other paleoenvironments but are very similar in shape to the Río Mao specimens. For these deeper water forms (Pl. 2, figs. 18, 19), H:L is 0.72 to 0.73 on average. Pliocene valves of deeper marine deposits of the Cañada Zalaya section (Pl. 2, figs. 20, 21) are similar in both size and shape to other deeper water forms, except that the ventral margin tends to be flatter.

Comparison.—Jung (1969) noted that small caryocorbulids of the Miocene and Pliocene of Trinidad were oversplit and considered *Corbula smithiana* Maury, 1912, and possibly *C. caribaea pergrata* Maury, 1925 and *C. daphnis* Maury, 1925, to be junior synonyms of *C. helenae* Maury, 1912. Although it is similar in shape to Río Cana morphologies of *C.*

sericea, C. helenae has a larger maximum size (up to 13 mm long), is more elongate, is less inflated, can be more coarsely sculptured, can have more prominent radial striations, and tends to have a more bulbous and projecting anterior. The species *C. manzanillensis* Maury, 1925 of the Miocene Manzanilla Formation of Trinidad is very small, has coarser ribs at comparable sizes, is strongly triangular, and less elongate than *C. sericea.*

Corbula (*Caryocorbula*) *oropendula* Olsson, 1922 has coarser sculpture, has a straighter keel and more ventrally located rostrum, is more elongate, and has a more strongly and evenly rounded ventral margin than *C. sericea. Corbula* (*Caryocorbula*) *oropendula dolicha* Woodring, 1982 is similar in shape to *C. oropendula* but has finer sculpture. *Corbula* (*Caryocorbula*) *oropendula stena* Woodring (1982) is much more rounded, tends to be smaller, and its rostrum creates a more prominent notch in the ventral margin than seen in *C. sericea.*

Occurrence.—This species was collected from the following areas (see Saunders *et al.*, 1986 for locality information):

Río Cana: Cercado Formation: TU 1230, and NMB 16838, 16839, 16841, 16843, 16844, 16845, 16846, 16848, 16850, 16851, 16853, 16854, 16855, 16856, 16986, 16987, 16988, 16989, 16990, 16993, 17001, 17003. Lower Gurabo Formation: NMB 16832. Upper Gurabo Formation: TU 1354, and NMB 16865, 17009.

Río Gurabo: Cercado Formation: TU 1277, 1419, and NMB 15900, 15904, 15910, 15911, 15912, 15925. Lower Gurabo Formation: TU 1211, 1215, 1278, and NMB 15842, 15846, 15854, 15860, 15863, 15864, 15869, 15871, 15873, 15882, 15936, 15937, 15941, 15944, 15945, 15947, 16808, 16809, 16810, 15836, 15835, 15952. Upper Gurabo Formation: TU 1210, and NMB 15933, 15935, 15939, 15964, 15966, 15969, 15805, 15804, 15814, 15815. Mao Formation: TU 1352, and NMB 15822, 15827, 15832, 15833.

Río Mao: Cercado Formation: TU 1294, and NMB 16912, 16913, 17269 (all correspond to Maury's Bluff 3 (1917)); NMB 16915, 16916, 16917, 16918, 16922, 16923, 16924, 16926, 16927, 16928 (all Arroyo Bajón); NMB 16914, 16929, 16930, 16931, 16932 (all Maury's Bluff 2); NMB 16802 (located between Bluff 1 and 2); TU 1293, and NMB 16910 (all Bluff 1), and TU 1225 (down stream and up section from Bluff 1).

Río Amina: Gurabo Formation: TU 1219, 1411, 1412.

Cañada Zalaya: Gurabo Formation: TU 1227, 1227A, 1453, 1453A.

Río Verde: Gurabo Formation: TU 1250.

Río Yaque del Norte: Baitoa Formation: TU 1226. Unnamed Formation: NMB 17273 (Arroyo López), NMB 17278 (Angostura). Gurabo Formation: TU 1403, 1405, 1448, 1449 (La Barranca), TU 1206 (Santiago).

Distribution.—Upper Lower to lower Middle Miocene Baitoa, Upper Miocene Cercado, Upper Miocene to Lower Pliocene Gurabo, and Lower Pliocene Mao Formations, Dominican Republic; Pliocene Bowden Formation, Jamaica; Pliocene Moín Formation, Costa Rica; Miocene Gatun Formation (?), Panama (see Brown and Pilsbry, 1911).

Subgenus **JULIACORBULA**
Olsson and Harbison, 1953

Juliacorbula Olsson and Harbison, 1953, p. 148–149.

Type species.—*Corbula aequivalvis* Philippi, 1836 (= *Corbula cubaniana* Orbigny, 1846; = *Corbula knoxiana* Adams, 1852b); by original designation. Recent, West Indies.

Diagnosis.—Shell small- to medium-sized, nearly equivalved. Subrectangular with strong keel and sharply truncated posterior. Well-defined escutcheon located behind beak. Hinge as in *Caryocorbula.* (See Olsson and Harbison, 1953; Olsson, 1961.)

Remarks.—*Juliacorbula* differs from *Caryocorbula* in shape and in the presence of an escutcheon. The type species was originally designated as *C. cubaniana,* which generally is agreed to be a junior synonym of *C. aequivalvis* (see McLean, 1951; Weisbord, 1964; Rios, 1975). The geologic range of *Juliacorbula* is Miocene to Recent in the West Indies, eastern Pacific, Central and South America, and Florida (Moore, 1969; Olsson and Harbison, 1953). Members of this group inhabit shallow-marine environments.

Corbula (Juliacorbula) fossilis Pilsbry, 1922
Plate 2, figures 22–26

Corbula contracta Say. Gabb, 1873b, p. 247.
Corbula knoxiana fossilis Pilsbry, 1922, p. 427, pl. 46, fig. 14.
?*Corbula* (*Cuneocorbula*) *cubaniana* Orbigny. Maury, 1925, p. 103–104, pl. 20, figs. 2–4.
?*Juliacorbula aequivalvis* (Philippi). Jung, 1969, p. 410–411, pl. 39, figs. 11–15.
Corbula (*Juliacorbula*) *aequivalvis* Philippi. Perrilliat, 1984, p. 17, pl. 16, figs. 1–4.

Diagnosis.—Species characterized by straight to slightly concave ventral margin, strongly angled posterior margin, strong keel and rostrum, and subtrapezoidal shape.

Description.—Valves relatively small, subtrapezoidal, and moderately inflated. Ventral margin flattened to slightly concave at midline. Dorsoanterior margin also slightly concave in front of umbo. Directly posterior of beak, valve margin planar, gently sloping ventrally (sloping more steeply in left valves) to rostrum so that rostrum nearly as high as entire valve. Posterior of rostrum, valve margin nearly planar and vertical. Keel sharp and gently sinuous. Valve ornament of relatively coarse ribs with steep dorsal and gentle ventral slopes. Faint radial striations present on umbo.

Right valve hinge with moderately projecting, triangular, hook-shaped, cardinal tooth directly beneath beak. Posterior socket-like resilifer present beneath umbo. Hinge plate strongly sinuous, making resilifer nearly obsolete. Posterior of hinge, long L-shaped furrow present on right valve's posterior margin for reception of left valve. Left valve hinge with large, triangular, cardinal socket beneath beak and posterior broad chondrophore. Dorsal surface of chondrophore with anterior, midline and posterior ridges; small denticle present at end of posterior ridge. Adductor muscle scars large and moderately thickened; anterior scar ovate, posterior scar circular. Pallial sinus obsolete.

Type Material.—Holotype: ANSP 2689 (right valve). Figure by Pilsbry (1922, Pl. 46, fig. 14) and refigured here (Pl. 2, figs. 22, 23).

Type locality.—None designated. It is here designated as NMB 15914: Cercado Formation (Upper Miocene), Río Gurabo, Dominican Republic.

Material.—Measured and/or figured specimens: NMB G 14124, 14125.

Measurements.—See Table 5.

Remarks.—This rare species is found in shell-rich sediments with a silty matrix.

Comparison.—Species of *Juliacorbula* from the Tertiary of Trinidad (Maury, 1925; Jung, 1969) are very similar to the Dominican species, although the posterior slope is nearly vertical in the Trinidad specimens and more oblique in Dominican forms. It is not possible at this time to determine whether this difference is of taxonomic significance because of the paucity of material. *Corbula* (*Juliacorbula*) *scutata* Gardner, 1943 of the Florida Pleistocene is very similar to *C. fossilis* but has coarser ribs, a more arched and less sinuous keel, a less concave dorsoanterior margin, and can be more elongate. The Pleistocene to Recent *C. aequivalvis* Philippi, 1836 (=*C. knoxiana* C. B. Adams, =*C. cubaniana* Orbigny) may be a peramorphic descendent of *C. fossilis*. Smaller specimens of *C. aequivalvis* overlap in morphology with *C. fossilis*. *Corbula aequivalvis* differs from *C. fossilis*, however in attaining a larger size, having a more rounded ventral margin that shows its greatest convexity anterior of the midline, not having a concave dorsoanterior margin, being more elongate, having a more sinuous keel, and tending to have finer ribs.

Table 5.—Measurements of *Corbula* (*Juliacorbula*) *fossilis*. Figures are in mm.

specimen	*valve*	*length*	*height*	*width*
ANSP 2689: holotype (Pl. 2, figs. 22, 23)	right	8.7	6.1	2.7
ANSP uncat.: paratype (Pl. 2, fig. 24)	left	8.4	5.8	2.8
ANSP uncat.: paratype	left	6.7	4.4	1.8
NMB G 14124: (Pl. 2, fig. 26); NMB locality 15914	right	5.7	4.1	1.6
NMB G 14125: (Pl. 2, fig. 25); NMB locality 16817	right	5.6	3.7	1.4
USNM 306431: (figured in Perrilliat, 1984); IGM locality 2851	left	8.7	6.8	2.2
PRI 870: (figured in Maury, 1925)	left	6.2	4.3	1.9
PRI 871: (figured in Maury, 1925)	right	7.4	5.1	2.3
PRI 872: (figured in Maury, 1925)	right	7.9	6.0	2.7

Occurrence.—This species was collected from the following areas (see Saunders et al., 1986 for locality information):

Río Cana: Upper Gurabo Formation: NMB 16817.

Río Gurabo: Cercado Formation: NMB 15914.

Distribution.—Upper Miocene Cercado, Upper Miocene to Lower Pliocene Gurabo Formations, Dominican Republic; Upper Miocene Santa Rosa beds, Veracruz, Mexico; Lower Pliocene Melajo Clay Member of the Springvale Formation(?), Pliocene Point Courbaril Sand and Clay Member of the l'Enfer Formation (?), Pliocene Matura Sand and Clay Member of the Talparo Formation (?), Trinidad.

Subgenus **PANAMICORBULA** Pilsbry, 1932

Panamicorbula Pilsbry, 1932, p. 105.

Type species.—*Potamomya inflata* Adams, 1852a (=*P. aequalis* Adams, 1852a, =*P. trigonalis* Adams, 1852a, = *Corbula macdonaldi* Dall, 1912); by original designation. Recent, Pacific Coast of Panama.

Diagnosis.—Valves moderately large and inflated but relatively thin, not rostrate. Surface smooth or with very fine concentric ribs. Hinge of right valve with anterior cardinal tooth and posterior socket-like resilifer. Left valve hinge with anterior cardinal socket and posterior chondrophore. (See Pilsbry, 1932; H. Vokes, 1945; Olsson, 1961.)

Remarks.—Contrary to the original description, no lateral teeth are present. What Pilsbry (1932) described as long laterals in the right valve are actually buttresses for grooves that receive the dorsal margin of the left valve (H. Vokes, 1945; Moore, 1969). Living *Panamicorbula* are found in the Panamic Province (eastern

Pacific; Mazatlán to Peru) in brackish water (Pilsbry, 1932; Olsson, 1961). The subgenus is reported as abundant but poorly preserved from Middle Miocene sediments at Punta Judas, Pacific Coast, Costa Rica (Seyfried et al., 1985). It is also present in USNM collections (with U.S. Geological Survey locality numbers) of the Lower Pliocene l'Enfer Formation (USGS 21842, USGS 20433) and Lower Pliocene Springvale Formation (USGS 20421, USGS 21083, USGS 20423) of Trinidad.

Corbula (Panamicorbula) canae, new species
Plate 3, figures 1–10

Corbula (*Panamicorbula*) aff. *C. inflata* (C. B. Adams). Anderson, 1994, fig. 3.1.

Diagnosis.—Species characterized by roughly triangular shape, thin valves, fine concentric ribs, and left and right valves subequal in size and shape.

Description.—Valves relatively large (maximum length about 15 mm), inflated, and thin. Left and right valves subequal in size and shape; right valve slightly larger. Valve height shows positive allometry relative to valve length; larger valves more triangular, whereas smaller valves more quadrate. Ventral margin most convex anterior of midline, whereas umbo located at midline. Ventral margin of right valve rounded, of left valve slightly sinuous. Valve ornament of very fine, closely-spaced, concentric ribs. Radial ribs absent. Arcuate keel and subtle rostrum present. Right valve hinge with large, anterior, triangular, hook-shaped, cardinal tooth. Posterior, socket-like resilifer present beneath beak and opening ventrally. Elongate furrow present on both sides of right valve hinge for reception of left valve. Left valve hinge with large, anterior, triangular, cardinal socket and broad posterior chondrophore. Chondrophore continuous with valve margin and not strongly projecting. Low anterior, midline, and posterior ridges present on dorsal surface of chondrophore. Adductor muscle scars large but not thickened. Posterior scar circular; anterior scar ovate. Pallial sinus obsolete.

Etymology of name.—Name after Río Cana.

Type Material.—Holotype: NMB G 14126 (articulated shell). Figured in Plate 3, figures 1, 2.

Type locality.—NMB 16845: Cercado Formation (Upper Miocene), Río Cana, Dominican Republic. Paratypes are from NMB 16841, a nearby locality in the same lithologic unit.

Material.—Measured and/or figured specimens: NMB G 14126, 14127, 14128, 14129, 14130, 14131, 14132. Other specimens (11 articulated shells, 32 right valves, and 20 left valves) are cataloged by locality, which are listed in the Occurrence section.

Table 6.—Measurements of *Corbula* (*Panamicorbula*) *canae*. Figures are in mm.

specimen	*valve*	*length*	*height*	*width*
NMB G 14126: holotype (Pl. 3, figs. 1, 2); NMB locality 16845	articulated	14.4	11.8	9.6[1]
NMB G 14127: paratype (Pl. 3, figs. 6, 7); NMB locality 16841	left	12.2	9.9	3.6
NMB G 14128: paratype (Pl. 3, fig. 8); NMB locality 16841	left	13.5	10.4	4.3
NMB G 14129: paratype (Pl. 3, fig. 5); NMB locality 16841	right	13.9	11.2	4.8
NMB G 14130: paratype (Pl. 3, figs. 3, 4); NMB locality 16841	right	12.4	10.2	3.4
NMB G 14131: (Pl. 3, fig. 9); NMB locality 16841	left	8.3	7.0	2.3
NMB G 14132: (Pl. 3, fig. 10); NMB locality 16841	right	7.1	5.5	1.5

[1] diameter of articulated shell.

Measurements.—See Table 6.

Remarks.—This is the first description of a fossil *Panamicorbula* species and the first description of a Caribbean *Panamicorbula.* This species is restricted to the "*Arca*" beds of the Upper Miocene Cercado Formation Río Cana section (see Saunders et al., 1986). It is found in interbedded shelly silts and silty clays, and in shell beds. Living representatives of *Panamicorbula* are restricted to the Pacific coast of Central America where they inhabit mangrove swamps and areas near the mouths of streams (Pilsbry, 1932; H. Vokes, 1945; Keen, 1971). *Corbula canae* apparently had similar environmental preferences because it occurs in sediments deposited in or near mangrove swamps (Anderson, 1994).

Comparison.—*Corbula* (*Panamicorbula*) *inflata* (Adams, 1852a) (synonyms: *C. aequalis* [Adams, 1852a], *C. trigonalis* [Adams, 1852a], and *C. macdonaldi* Dall, 1912) is much larger than *C. canae* and differs somewhat in shape. The ventral margin of *C. inflata* (Adams, 1852a) is flatter and is most convex near the valve midline, the keel is less arcuate, and the rostrum is absent.

Occurrence.—This species was collected from the following areas (see Saunders et al., 1986 for locality information):

Río Cana: Cercado Formation: NMB 16843, 16845, 16990, 16841, 16993, 16987, 16989, 16840, 16844, 16852, and 16842.

Distribution.—Upper Miocene Cercado Formation, Dominican Republic.

Corbula (Panamicorbula) sp.
Plate 3, figure 11

Diagnosis.—Small uninflated valves (< 6.5 mm) of *Panamicorbula* with rectangular shape.

Table 7.—Measurements of *Corbula* (*Panamicorbula*) sp. Figures are in mm.

specimen	*valve*	*length*	*height*	*width*
NMB G 14133: (Pl. 3, fig. 11); NMB locality 16990	right	5.4	4.0	1.3

Material.—Measured and/or figured specimens: NMB G 14113. Other specimens (15 right valves, and 4 left valves) are cataloged by locality, which are listed in the Occurrence section.

Measurements.—See Table 7.

Remarks.—These are small, apparently immature valves of a *Panamicorbula* species. Although these valves may be small individuals of *Corbula* (*Panamicorbula*) *canae,* the small number of valves for comparison and lack of intermediates makes assignment uncertain. These valves co-occur with *C. canae* in interbedded shelly silts and silty clays, and shell beds dominated by *Anadara patricia* in the upper part of the Upper Miocene Cercado Formation of the Río Cana section.

Comparison.—Valve shape of *Corbula* (*Panamicorbula*) sp. resembles *Caryocorbula,* but these valves are not as inflated as *Caryocorbula,* and the resilifer of the right valve opens ventrally (as in *Panamicorbula*). These valves differ from *Corbula* (*Panamicorbula*) *canae* in that they are small, much less inflated, and rectangular (rather than triangular) in shape.

Occurrence.—This species was collected from the following areas (see Saunders *et al.*, 1986 for locality information):

Río Cana: Cercado Formation: NMB 16845, 16990, 16993, 16987, 16989, 16846, 16852, 16986.

Distribution.—Upper Miocene Cercado Formation, Dominican Republic.

Subgenus **VARICORBULA** Grant and Gale, 1931

Varicorbula Grant and Gale, 1931, p. 420, footnote 1.

Type species.—*Tellina gibba* Olivi, 1792; by original designation. Recent, west coast of Europe and Mediterranean Sea.

Diagnosis.—Valves small to moderate in size with right and left valves strongly unequal in size, shape, and ornamentation. Right valve larger, more inflated and relatively higher; left valve smaller, more elongate, and much less inflated. Right valves with strongly expressed concentric ribs. Left valves with fine, widely spaced, radial ribs and fine concentric growth-lines; thicker concentric ribs may be present on beak and umbo. Right valve hinge with anterior cardinal tooth and posterior socket-like resilifer. Left valve hinge with anterior cardinal socket and posterior chondrophore.

Remarks.—Some workers (Stenzel *et al.*, 1957; Weisbord, 1964; Jung, 1969) consider *Varicorbula* to be a junior synonym of *Notocorbula* Iredale, 1930. Woodring (1982), however, advocated continued use of *Varicorbula* until the type species of *Notocorbula* was better known. Stenzel *et al.* (1957) state that the nepionic shells evident in both valves of the type species, *Corbula* (*Notocorbula*) *vicaria* (Iredale, 1930), can be seen in a more subdued form in *C. gibba* (Olivi, 1792), the type species of *Varicorbula,* and use this trait as a basis for synonymy. *Corbula vicaria,* however, does apparently differ from *C. gibba* in that left and right valves are subequal in size and shape, whereas *Varicorbula* is strongly inequivalved. Therefore, *Varicorbula* is used here.

The geologic range of *Varicorbula* is Eocene to Recent in eastern North America, Europe, and the eastern and western Pacific (Moore, 1969). *Varicorbula* species inhabit marine waters and can locally dominate the benthic fauna (*e.g.,* Yonge, 1946).

Corbula (Varicorbula) sanctidominici Maury, 1925
Plate 3, figures 12–18

Corbula disparilis Orbigny. Gabb, 1873b, p. 247.
Corbula vieta Guppy. Pilsbry, 1922, p. 427.
Corbula (*Aloidis*) *vieta* Guppy. Maury, 1917, p. 231–232, pl. 39, fig. 13.
Corbula (*Aloidis*) *sancti-dominici* Maury, 1925, p. 98–99, pl. 19, fig. 2.
Corbula (*Varicorbula*) *vieta* Guppy. Anderson, 1994, fig. 3.2.

Diagnosis.—Species characterized by highly inflated right valve with concave dorsoanterior slope, evenly rounded ventral margin, relatively narrow and anteriorly directed umbo, and near absence of rostrum and keel. Left valve characterized by quadrate shape and uninflated umbo.

Description.—Shells of moderate size. Valves strongly inequivalved in size, shape, and ornamentation. Right valve larger, greatly inflated, and subtriangular. Right valve also with very subtle to obsolete keel and rostrum, evenly spaced moderately coarse flat-topped concentric ribs, and evenly convex ventral margin. Valve shape varies with size. Small right valves inflated with concave dorsoanterior slope, umbo directed anteriorly, and obsolete keel. Inflation increases, dorsoanterior slope becomes less concave, and umbo becomes more dorsally oriented with increasing size. Subtle keel and slight rostrum also develop as size increases.

Left valves more elongate and quadrate, and much less inflated than right. Left valves with faint, concentric growth lines and widely spaced and slightly more distinct radial striations. Radial striations absent on posterior slope. Small left and right valves (2–3 mm in length) very similar in shape, but radial ribs more prominent on left valves and concentric ribs more prominent on right valves. As size increases, left valves become more quadrate and keel become more strongly expressed.

Hinge of right valve with small, blunt, anterior cardinal tooth directly beneath beak and posterior, broad, socket-like resilifer that extends slightly beneath beak. Resilifer, appears reduced because hinge plate concave. Subsidiary denticle may occur above cardinal tooth, formed by projection of valve margin beneath beak. Furrows present on either side of right valve hinge for reception of left valve. Left valve hinge with an anterior small subtriangular socket, and posterior broad chondrophore. Dorsal surface of chondrophore with prominent anterior ridge, more subdued midline ridge, and posterior ridge with small denticle. Posterior portion of chondrophore projects strongly upward and may be visible externally. Muscle scars not thickened. Posterior scar circular; anterior scar ovate. Pallial sinus obsolete.

Type Material.—Holotype: PRI 903 (right valve). Figured by Maury (1917, Pl. 39, fig. 13; 1925, Pl. 19, fig. 2), and refigured here (Pl. 3, fig. 12).

Type locality.—Río Cana at Caimito, Dominican Republic (designated by Maury, 1925). The type locality is here restricted to TU 1230: Cercado Formation (Upper Miocene), Río Cana, Dominican Republic (fide Jung, 1986).

Material.—Measured and/or figured specimens: NMB G 14134, 14135, 14136, 14137. Other specimens (over 1,100) are cataloged by locality, which are listed in the Occurrence section.

Measurements.—See Table 8.

Remarks.—*Corbula sanctidominici* typically occurs scattered in silts and in bioclastic beds with a silty matrix. This species also occurs in bioclast-rich lenses and burrow-fills within silts.

The literature for Caribbean Neogene and Quaternary *Varicorbula* is complex. Of primary concern here are whether *Corbula* (*Varicorbula*) *sanctidominici* is a junior synonym of 1) *C. vieta* Guppy, 1866a, a species originally described from the Miocene Manzanilla Formation of Trinidad, or 2) *C. operculata* Philippi, 1848 (=*C. disparilis* Orbigny, 1846?), a Recent Atlantic species. Gabb (1873b) placed *Varicorbula* from the Dominican Republic in *C. disparilis* and also considered *C. vieta* to be a junior synonym of *C. disparilis*. Recent specimens of *Varicorbula* of the western Atlantic represent a taxonomic quandary, and they have been variously assigned to *Corbula disparilis* Orbigny, 1846?; *C. operculata* Philippi, 1848; and *C. philippii* Smith, 1885 (see Weisbord, 1964 and Woodring, 1982 for discussion). The synonymy of these names is not controversial, although authors differ on which is senior. Woodring (1982) states that Orbigny's illustration is poor and the dates of publication controversial; the imprinted date is 1846, although the probable publication date is 1853 (Keen, 1971). Those who doubt the 1846 publication date use *C. operculata* Philippi, 1848 for this species. However named, the Recent species appears distinct from *C. vieta* s. s. and *C. sanctidominici,* because it attains a larger maximum size, is more elongate in shape with gentler anterior and posterior dorsal slopes, has coarser ribs, and has a stronger rostrum and keel.

Table 8.—Measurements of *Corbula* (*Varicorbula*) *sanctidominici*. Figures are in mm.

specimen	*valve*	*length*	*height*	*width*
PRI 903: holotype (Pl. 3, fig. 12)	right	9.5	9.6	5.1
NMB G 14135: (Pl. 3, figs. 13, 18); NMB locality 16837	right	7.8	7.9	4.6
NMB G 14134: (Pl. 3, figs. 16, 17); NMB locality 16837	left	4.6	4.0	1.7
NMB G 14136: (Pl. 3, fig. 14); TU locality 1250	right	5.5	5.4	2.6
NMB G 14137: (Pl. 3, fig. 15); TU locality 1250	right	4.4	4.1	2.0

Pilsbry (1922), in his revision of Gabb's Dominican species, concurs with Dall (1898) that *C. vieta* and *C. disparilis* are not synonymous, and assigned Gabb's specimens to *C. vieta.* Maury (1917) first placed her Dominican *Varicorbula* in *C. vieta,* but later (Maury, 1925) considered her Dominican form to be distinct, and named it *C. sanctidominici.* Maury (1925) stated that her Dominican specimen was larger (10 mm long, 10 mm high compared to 6 mm × 6 mm for *C. vieta* from the type area), more inflated, and had more numerous (about 26 rather than about 25) and more closely spaced ribs. Maury (1925), however, did not place Gabb's (1873b) Dominican *Varicorbula* specimens in synonymy with *C. sanctidominici,* stating they are either *C. vieta* or *C. sanctidominici.*

The type material of *C. vieta* (USNM 115650; left valves of *C. vieta* were assigned to *Erycina tensa* Guppy, 1866a, USNM 115652) are not well preserved, and the margins of the larger right valve are not complete, making comparison difficult. *Corbula vieta* from the type locality shows the same size range as Dominican varicorbulids, but tends to be more elongate, have a wider umbo, less concave dorsoanterior slope, and stronger keel.

The material from this study agrees well with Gabb's (1873b) material (ANSP 2690) from the Dominican Republic. Maury's type (PRI 903) of *C. sanctidominici* is, however, somewhat unusual for Dominican *Varicorbula.* Her specimen is a right valve that is unusually large and coarsely ribbed. Unfortunately, the ventral margin is not intact so it is difficult to determine original valve shape, a diagnostic feature. Nevertheless, the traits that Maury noted as diagnostic for *C. sanctidominici* seem to be correlated with size in Dominican *Varicorbula*. Therefore, I place both my material and Gabb's Dominican material in *C. sanctidominici*.

Comparison.—*Corbula* (*Varicorbula*) *sanctianderaea* Maury (1925) of the Miocene Manzanilla Formation of Trinidad has a left valve with a very convex beak that is subequal in size to the right valve's beak. In addition, the right valve of *C. sanctianderaea* is relatively more elongate and subequilateral with a wider umbo and stronger rostrum than *C. sanctidominici*.

Corbula heterogena Guppy (in Dall, 1898) of the Pliocene Bowden Formation of Jamaica is very similar in size and shape to *C. sanctidominici*. In *C. heterogena*, however, the umbos of the right valve are less elevated and prominent, and are not as strongly directed anteriorly because the dorsoanterior margin is less concave. Therefore, in *C. sanctidominici* the right valve umbo appears narrower and more set off from the ventral portion of the valve. In addition, the right valve of *C. heterogena* is more elongate and has a stronger rostrum and keel. The left valves of *C. heterogena* are more inflated and have more prominent beaks.

Woodring (1982) assigns specimens of the Miocene and Pliocene of Panama and Costa Rica to *Corbula* (*Varicorbula*) *disparilis*. He also considered *C. waltonensis* Gardner, 1928 from the Miocene of Florida a junior synonym of *C. disparilis*, thus allowing much morphologic variation in the species. Woodring's (1982) figured specimens are very similar to *C. heterogena*. These Central American forms differ from *C. sanctidominici* in having a stronger rostrum and keel, beaks directed dorsally rather than anteriorly, and a somewhat sinuous rather than straight ventral margin.

Occurrence.—This species was collected from the following areas (see Saunders *et al.*, 1986 for locality information):

Río Cana: Cercado Formation: TU 1230, and NMB 16835, 16838, 16837, 16842, 16857, 17005. Lower Gurabo Formation: NMB 16828, 16832, 16833, 16834. Upper Gurabo Formation: TU 1354, and NMB 16817, 16818, 16959, 16824.

Arroyo Ballaco: Cercado Formation: TU 1420.

Río Gurabo: Cercado Formation: NMB 15895, 15896, 15906, 15900. Lower Gurabo Formation: TU 1215, 1277, 1211, and NMB 15846, 15860, 15863, 15864, 16810, 15869, 15871, 15873, 15874, 15878, 15882, 15836, 15944, 15952, 15954. Upper Gurabo Formation: TU 1210, and NMB 15804, 15805.

Río Mao: Cercado Formation: NMB 16927, 16915, 16926, 16924 (all correspond to Arroyo Bajón); NMB 16929, 16914 (all Maury's Bluff 2); TU 1410, and NMB 16802 (between Maury's Bluff 1 and 2); TU 1293, NMB 16910 (Maury's Bluff 1); TU 1225 (downstream of Maury's Bluff 1).

Cañada Zalaya: Gurabo Formation: TU 1227, 1227a, 1453, 1453a.

Río Yaque del Norte: Baitoa Formation: TU 1363, and NMB 16938 (all López section). Unnamed Formation: NMB 17273 (Arroyo López). Gurabo Formation: TU 1449, 1448, 1405, 1403 (La Barranca); TU 1206 (Santiago).

Río Verde: Gurabo Formation: TU 1250.

Distribution.—Upper Lower to lower Middle Miocene Baitoa, Upper Miocene Cercado, Upper Miocene to Lower Pliocene Gurabo Formations, Dominican Republic.

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APPENDIX 1

Criteria used to distinguish four environmental categories, based on the paleoenvironmental interpretations of Saunders *et al.* (1986) and Bold (1988) primarily using macrofossil and microfossil assemblages.

Brackish:	Characterized by mollusks such as *Larkinia, Mytilus,* and *Melongena, Anadara patricia,* and brackish-water ostracodes.
Shallow:	Depths approximately 0–30 m. Characterized by shallow-marine benthic foraminifera (*Amphistegina,* soritids, miliolids), shallow-marine mollusks (*Pachycrommium, Stigmaulux, Anadara, Tellina, Strombina*) and shallow-marine ostracodes (*Cytherella, Radimella, Caudites, Proteoconcha, Loxoconcha, Paracytheridea*). Planktonic foraminifera and calcareous nannofossils are absent.
Intermediate:	Depths approximately 30–100 m. Characterized by abundant and diverse assemblage of shallow-water ostracodes, benthic foraminifera, corals, mollusks (including *Strombus, Oliva, Polystira,* and *Lyria*), and a few planktonic foraminiferal species.
Deep:	Depths > 100 m. Characterized by rich assemblage of planktonic foraminifera, high ratios of planktonic to benthic foraminifera, deep water ostracodes (e.g., *Krithe*), and pteropods.

APPENDIX 2

Samples used for analyses illustrated in Text-figures 4–6. Samples selected to provide broad stratigraphic coverage. Abbreviations are as follows:

Section = Stratigraphic section; Cana = Río Cana; Gurabo = Río Gurabo; Mao = Río Mao; Yaque = Río Yaque del Norte; Zalaya = Cañada Zalaya.

Formation = Geologic Formation. If blank, Saunders *et al.* (1986) did not assign.

Age = Geologic age.

Environment = Environmental category (for *Corbula sericea*). See Appendix 1 for criteria used to distinguish categories.

Sed. Type = Sediment type (for *Corbula viminea*). Categories are: 1 = silts with bioclasts in lenticular beds or lenses; 2 = silts with bioclasts filling burrows; 3 = silts with mollusks dispersed in matrix; 4 = silty sands with bioclasts dispersed or concentrated.

Valves = Number of valves used in each sample. If a sample contained less than 30 valves (left or right) all were measured. For *C. sericea,* if a sample contained more than 30 right valves, 30 were randomly selected. For *C. viminea,* if a sample contained more than 30 left or right valves, 30 of each were randomly selected. All selected valves were measured but due to missing data on less than pristine valves, not all may have been incorporated into the principal components analyses (PCA).

Corbula (*Caryocorbula*) *sericea*

section	*sample*	*formation*	*age*	*environment*	*valves*
Cana	NMB 16865	Gurabo	Pliocene	Intermediate	3
Cana	NMB 17009	Gurabo	Pliocene	Intermediate	4
Cana	NMB 16848	Cercado	Miocene	Brackish	25
Cana	TU 1230	Cercado	Miocene	Shallow	15
Cana	UW 1863/27	Cercado	Miocene	Shallow	22
Cana	NMB 16855	Cercado	Miocene	Shallow	27
Gurabo	NMB 15833	Mao	Pliocene	Deep	7
Gurabo	TU 1352	Mao	Pliocene	Deep	10
Gurabo	NMB 15805	Gurabo	Pliocene	Deep	24
Gurabo	NMB 15842	Gurabo	Miocene	Intermediate	10
Gurabo	NMB 15846	Gurabo	Miocene	Intermediate	10
Gurabo	NMB 15863	Gurabo	Miocene	Intermediate	12
Gurabo	NMB 16810	Gurabo	Miocene	Intermediate	17
Gurabo	NMB 15869	Gurabo	Miocene	Intermediate	21
Gurabo	NMB 15911	Cercado	Miocene	Shallow	1
Gurabo	NMB 15912	Cercado	Miocene	Shallow	1
Mao	NMB 16910		Miocene	Intermediate	5
Mao	NMB 16802		Miocene	Intermediate	7
Mao	NMB 16929		Miocene	Shallow	24
Mao	NMB 16928		Miocene	Shallow	25
Mao	UW 1863/25		Miocene	Shallow	25
Mao	UW 1863/26		Miocene	Shallow	23
Mao	NMB 16913		Miocene	Shallow	23
Yaque	TU 1206		Pliocene	Deep	16
Zalaya	TU 1227A		Pliocene	Deep	27
Yaque	TU 1403		Pliocene	Deep	16
Yaque	NMB 17278		Miocene	Shallow	2
Yaque	NMB 17273		Miocene	Brackish	3

Corbula (*Bothrocorbula*) *viminea*

section	*sample*	*formation*	*age*	*sed. type*	*valves*
Cana	NMB 16833	Gurabo	Miocene	3	28
Cana	NMB 16832	Gurabo	Miocene	3	5
Cana	NMB 16837	Cercado	Miocene	3	9
Cana	NMB 16838	Cercado	Miocene	3	3
Cana	TU 1230	Cercado	Miocene	3	53
Cana	NMB 16857	Cercado	Miocene	1	10
Cana	NMB 17005	Cercado	Miocene	1	4
Gurabo	NMB 15878	Gurabo	Miocene	1	4
Gurabo	TU 1297	Gurabo	Miocene	2	7
Gurabo	NMB 15882	Gurabo	Miocene	2	4
Gurabo	NMB 15906	Cercado	Miocene	1	47
Gurabo	NMB 15900	Cercado	Miocene	1	37
Mao	NMB 16915		Miocene	1	4
Mao	NMB 16917		Miocene	1	14
Mao	NMB 16923		Miocene	1	21
Mao	NMB 16927		Miocene	1	1
Yaque	TU 1445		Miocene	—	2
Yaque	NMB 16938	Baitoa	Miocene	3	5
Yaque	NMB 16936	Baitoa	Miocene	3	1
Yaque	NMB 16935	Baitoa	Miocene	4	1
Yaque	NMB 17289	Baitoa	Miocene	4	2
Yaque	TU 1364	Baitoa	Miocene	4	9
Yaque	TU 1363	Baitoa	Miocene	4	2
Yaque	NMB 17288	Baitoa	Miocene	3	2
Yaque	NMB 17286	Baitoa	Miocene	4	1

PLATES

EXPLANATION OF PLATE 1

Figure Page

1–8, 10, 11, 13, 14. **Corbula (Bothrocorbula) viminea** Guppy, 1866b 12

1, 4. Hypotype. NMB G 14110; from locality TU 1364: Río Yaque del Norte, upper Lower to lower Middle Miocene Baitoa Formation. Right valve: 1. interior, × 4⅓; 4. exterior, × 4. Length, 14.0 mm; height, 9.7 mm; width, 4.8 mm.

2, 5. Hypotype. NMB G 14109; from locality TU 1364: Río Yaque del Norte, upper Lower to lower Middle Miocene Baitoa Formation. Left valve: 2. interior, × 4⅓; 5. exterior, × 4⅔. Length, 13.3 mm; height, 9.3 mm; width, 3.8 mm.

3. Syntype. BMNH 64088. Bowden Formation, Jamaica. Right valve exterior. Length, 19.1 mm; height, 13.9 mm; width, 6.3 mm; × 3.

6. Syntype. BMNH 64099. Bowden Formation, Jamaica. Left valve exterior. Length, 15.1 mm; height, 10.3 mm; width, 5.0 mm; × 3.

7. Hypotype. NMB G 14108; from locality TU 1230: Río Cana, Upper Miocene Cercado Formation. Right valve exterior. Length, 14.2 mm; height, 9.9 mm; width, 5.2 mm; × 4.

8. Hypotype. NMB G 14107; from locality TU 1230: Río Cana, Upper Miocene Cercado Formation. Left valve exterior. Length, 14.1 mm; height, 9.7 mm; width, 5.0 mm; × 4⅓.

10. Hypotype. NMB G 14106; from locality NMB 15900: Río Gurabo, Upper Miocene Cercado Formation. Right valve exterior. Length, 16.3 mm; height, 11.5 mm; width, 6.0 mm; × 3.

11. Hypotype. NMB G 14105; from locality NMB 15900: Río Gurabo, Upper Miocene Cercado Formation. Left valve exterior. Length, 15.3 mm; height, 11.3 mm; width, 5.4 mm; × 3.

13. Hypotype. NMB G 14104; from locality NMB 16923: Río Mao, Upper Miocene Cercado Formation (Maury's Bluff 3). Right valve exterior. Length, 17.4 mm; height, 12.3 mm; width, 6.0 mm; × 4.

14. Hypotype. NMB G 14103; from locality NMB 16923: Río Mao, Upper Miocene Cercado Formation (Maury's Bluff 3). Left valve exterior. Length, 15.9 mm; height, 11.8 mm; width, 4.9 mm; × 4.

9, 12. **Corbula (Caryocorbula) dominicensis** Gabb, 1873b 14

9, 12. Hypotype. NMB G 14111; from locality NMB 17821: Río Yaque del Norte, upper Lower to lower Middle Miocene Baitoa Formation. Articulated shell: 9. right side; 12. left side. Length, 15.3 mm; height, 9.2 mm; width, 6.9 mm; × 4⅓.

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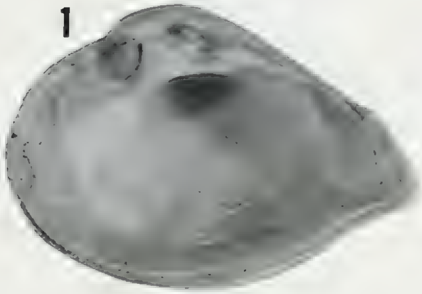

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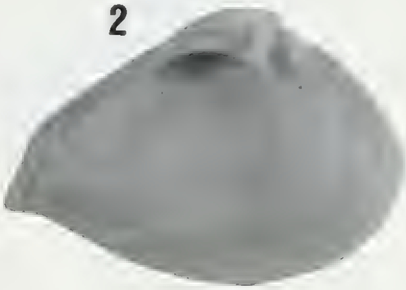

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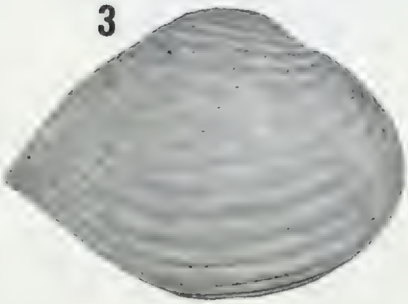

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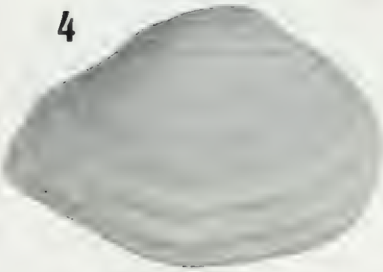

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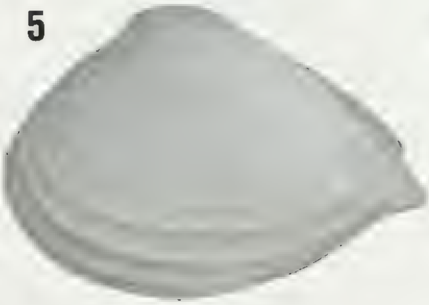

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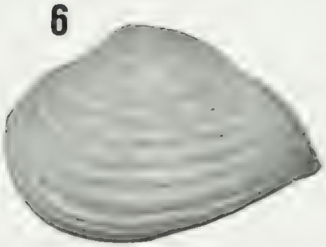

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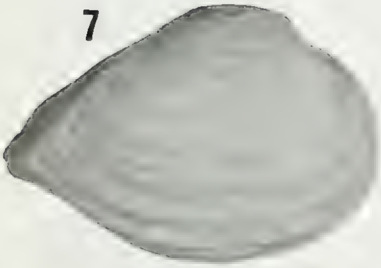

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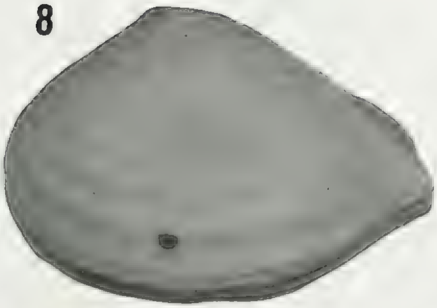

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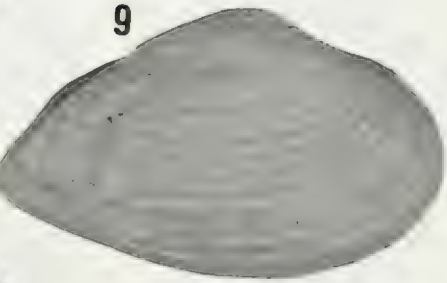

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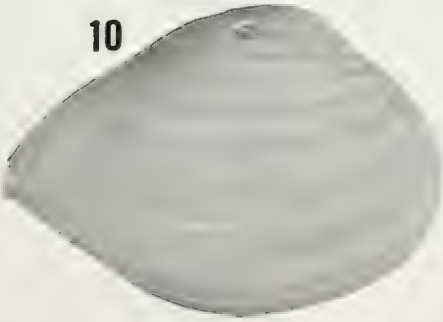

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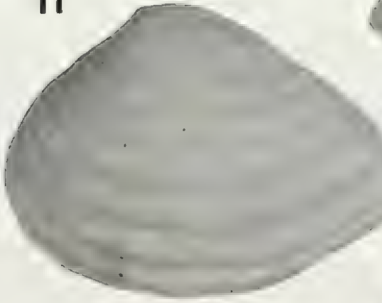

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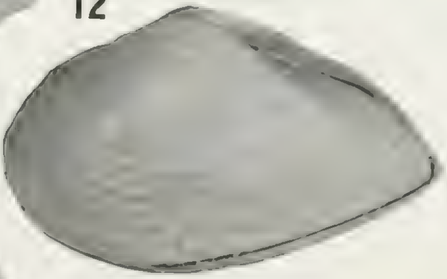

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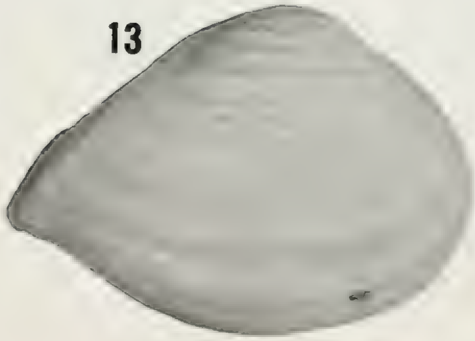

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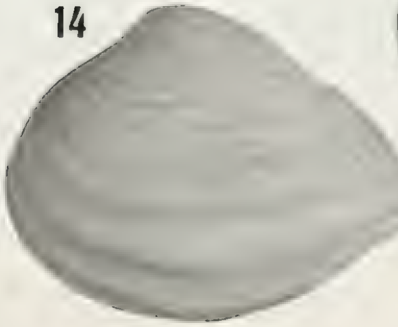

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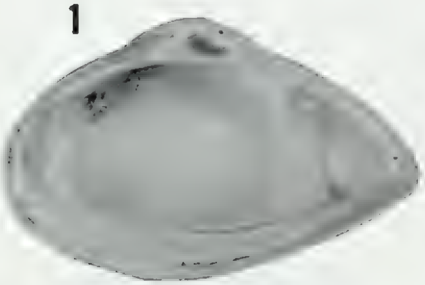
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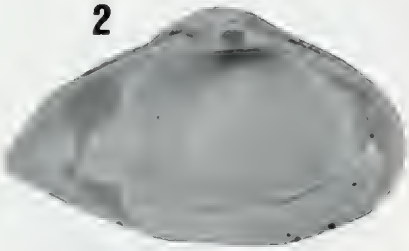
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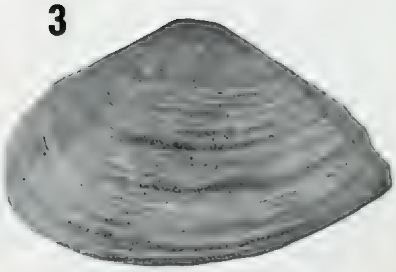
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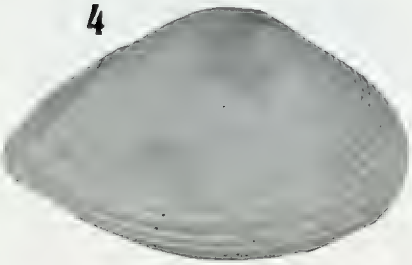
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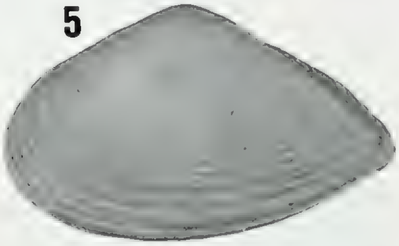
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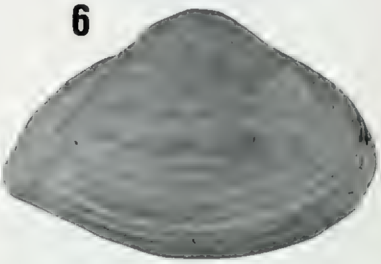
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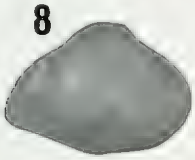
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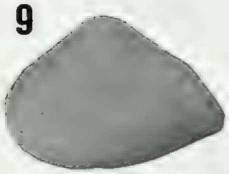
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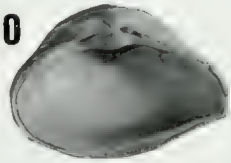
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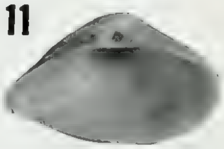
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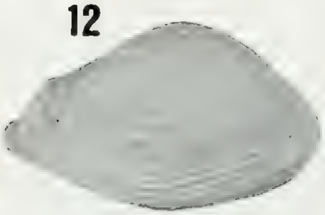
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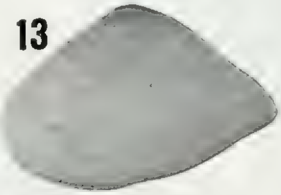
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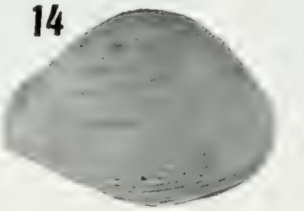
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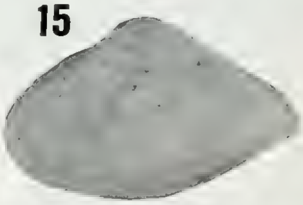
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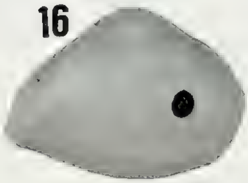
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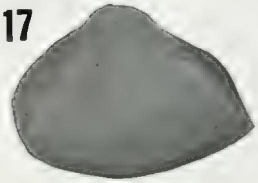
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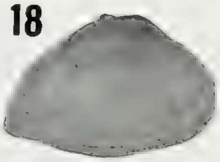
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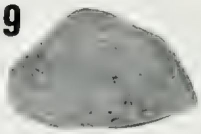
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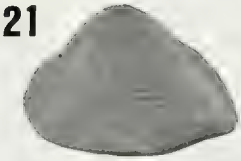
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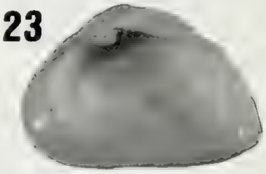
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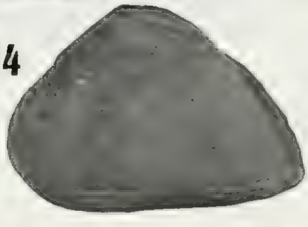
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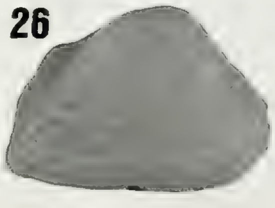

EXPLANATION OF PLATE 2

Figure Page

1, 2, 4, 5. **Corbula (Caryocorbula) dominicensis** Gabb, 1873b 14

1, 4. Hypotype. NMB G 14113; from locality TU 1226: Río Yaque del Norte, upper Lower to lower Middle Miocene Baitoa Formation. Right valve: 1. interior; 4. exterior. Length, 14.2 mm; height, 9.0 mm; width, 4.0 mm; × 4⅓.

2, 5. Hypotype. NMB G 14112; from locality TU 1226: Río Yaque del Norte, upper Lower to lower Middle Miocene Baitoa Formation. Left valve: 2. interior; 5. exterior. Length, 13.6 mm; height, 8.2 mm; width, 3.1 mm; × 4⅓.

3, 6. **?Corbula (Caryocorbula) dominicensis** Gabb, 1873b 14

3. Hypotype. PRI 29033. Río Cana, Upper Miocene Cercado Formation; figured in Maury (1917). Left valve exterior. Length, 13.4 mm; height, 8.6 mm; width, 3.3 mm; × 4⅓.

6. Hypotype. PRI 29033. Río Cana, Upper Miocene Cercado Formation; figured in Maury (1917). Right valve exterior. Length, 12.6 mm; height, 8.6 mm; width, 3.2 mm; × 4⅓.

7–21. **Corbula (Caryocorbula) sericea** Dall, 1898 15

7. Lectotype. USNM 135655. Moín Formation, Limón, Costa Rica. Right valve exterior. Length, 5.3 mm; height, 4.0 mm; width, 2.0 mm, × 4⅓.

8. Syntype of *Corbula* (*Cuneocorbula*) *cercadica* Maury, 1917 (mislabeled as *Corbula* (*Cuneocorbula*) *caimitica* Maury, 1917). PRI 29035. Río Mao, Upper Miocene Cercado Formation (Maury's Bluff 3). Right valve exterior. Length, 6.6 mm; height, 4.6 mm; width, 2.3 mm; × 4⅓.

9. Syntype of *Corbula* (*Cuneocorbula*) *cercadica* Maury, 1917 (mislabeled as *Corbula* (*Cuneocorbula*) *caimitica* Maury, 1917). PRI 29035. Río Mao, Upper Miocene Cercado Formation (Maury's Bluff 3). Left valve exterior. Length, 5.6 mm; height, 3.9 mm; width, 2.0 mm; × 5⅔.

10, 14. Hypotype. NMB G 14119; from locality NMB 16848: Río Cana, Upper Miocene Cercado Formation. Right valve: 10. interior, × 4⅓; 14. exterior, × 5⅔. Length, 7.0 mm; height, 5.0 mm; width, 3.0 mm.

11, 15. Hypotype. NMB G 14118; from locality NMB 16848: Río Cana, Upper Miocene Cercado Formation. Left valve: 11. interior, × 4⅓; 15. exterior, × 5⅔. Length, 7.5 mm; height, 4.7 mm; width, 2.4 mm.

12. Hypotype. NMB G 14121; from locality NMB 16855: Río Cana, Upper Miocene Cercado Formation. Right valve exterior. Length, 8.1 mm; height, 4.8 mm; width, 2.7 mm; × 5⅔.

13. Hypotype. NMB G 14120; from locality NMB 16855: Río Cana, Upper Miocene Cercado Formation. Left valve exterior. Length, 7.1 mm; height, 4.6 mm; width, 2.3 mm; × 5⅔.

16. Hypotype. NMB G 14115; from locality NMB 16928: Río Mao, Upper Miocene Cercado Formation (Arroyo Bajón). Right valve exterior. Length, 6.1 mm; height, 4.5 mm; width, 2.1 mm; × 5⅔.

17. Hypotype. NMB G 14114; from locality NMB 16928: Río Mao, Upper Miocene Cercado Formation (Arroyo Bajón). Left valve exterior. Length, 5.6 mm; height, 4.0 mm; width, 1.8 mm; × 6⅓.

18. Hypotype. NMB G 14117; from locality NMB 15869: Río Gurabo, Upper Miocene part of Gurabo Formation. Right valve exterior. Length, 4.9 mm; height, 3.2 mm; width, 1.6 mm; × 6⅓.

19. Hypotype. NMB G 14116; from locality NMB 15869: Río Gurabo, Upper Miocene part of Gurabo Formation. Left valve exterior. Length, 4.2 mm; height, 2.9 mm; width, 1.4 mm; × 6⅓.

20. Hypotype. NMB G 14123; from locality TU 1227A: Cañada Zalaya, Lower Pliocene part of Gurabo Formation. Right valve exterior. Length, 6.0 mm; height, 4.2 mm; width 2.3 mm; × 5⅔.

21. Hypotype. NMB G 14122; from locality TU 1227A: Cañada Zalaya, Lower Pliocene part of Gurabo Formation. Left valve exterior. Length, 5.6 mm; height, 3.9 mm; width 2.0 mm; × 5⅔.

22–26. **Corbula (Juliacorbula) fossilis** Pilsbry, 1922 17

22, 23. Holotype. ANSP 2689; Dominican Republic (locality unknown). Right valve: 1. exterior, 2. interior. Length, 8.7 mm; height, 6.1 mm; width, 2.7 mm; × 4.

24. Paratype. ANSP uncataloged; Dominican Republic (locality unknown). Left valve exterior. Length, 8.4 mm; height, 5.8 mm; width, 2.8 mm; x 5⅓.

25. Hypotype. NMB G 14125; from locality NMB 16817: Río Cana, Lower Pliocene part of Gurabo Formation. Right valve exterior. Length, 5.6 mm; height, 3.7 mm; width, 1.4 mm; × 7⅓.

26. Hypotype. NMB G 14124; from locality NMB 15914: Río Gurabo, Upper Miocene Cercado Formation. Right valve exterior. Length, 5.7 mm; height, 4.1 mm; width, 1.6 mm; × 6⅔.

EXPLANATION OF PLATE 3

Figure Page

1–10. **Corbula (Panamicorbula) canae** new species 19

1, 2. Holotype. NMB G 14126; from locality NMB 16845: Río Cana, Upper Miocene Cercado Formation. Articulated shell: 1. right side; 2. left side. Length, 14.4 mm; height, 11.8 mm; width, 9.6 mm; × 3⅔.

3, 4. Paratype. NMB G 14130; from locality NMB 16841: Río Cana, Upper Miocene Cercado Formation. Right valve: 3. exterior, 4. interior. Length, 12.4 mm; height, 10.2 mm; width, 3.4 mm; × 4⅓.

5. Paratype. NMB G 14129; from NMB 16841: Río Cana, Upper Miocene Cercado Formation. Right valve exterior. Length, 13.9 mm; height, 11.2 mm; width 4.8 mm, × 4⅓.

6, 7. Paratype. NMB G 14127; from locality NMB 16841: Río Cana, Upper Miocene Cercado Formation. Left valve: 6. exterior, 7. interior. Length, 12.2 mm; height, 9.9 mm; width, 3.6 mm; × 4⅓.

8. Paratype. NMB G 14128; from NMB 16841: Río Cana, Upper Miocene Cercado Formation. Left valve exterior. Length, 13.5 mm; height, 10.4 mm; width 4.3 mm; × 4⅓.

9. Hypotype. NMB G 14131; from NMB 16841: Río Cana, Upper Miocene Cercado Formation. Left valve exterior. Length, 8.3 mm; height, 7.0 mm; width, 2.3 mm; × 4⅓.

10. Hypotype. NMB G 14132; from NMB 16841: Río Cana, Upper Miocene Cercado Formation. Right valve exterior. Length, 7.1 mm; height, 5.5 mm; width, 1.5 mm; × 4⅓.

11. **Corbula (Panamicorbula)** sp. 19

11. Hypotype. NMB G 14133; from locality NMB 16990: Río Cana, Upper Miocene Cercado Formation. Length, 5.4 mm; height, 4.0 mm; width, 1.3 mm; × 4⅓.

12–18. **Corbula (Varicorbula) sanctidominici** Maury, 1925 19

12. Holotype. PRI 903. Río Cana, Cercado Formation. Right valve exterior. Length, 9.5 mm; height, 9.6 mm; width, 5.1 mm, × 4⅓.

13, 18. Hypotype. NMB G 14135; from locality NMB 16837: Río Cana, Upper Miocene Cercado Formation. Right valve: 13. exterior, × 4⅔; 18. interior, × 4⅓. Length, 7.8 mm; height, 7.9 mm; width, 4.6 mm.

14. Hypotype. NMB G 14136; from locality TU 1250: Río Verde, Lower Pliocene part of Gurabo Formation. Right valve exterior. Length, 5.5 mm; height, 5.4 mm; width, 2.6 mm, × 4⅓.

15. Hypotype. NMB G 14137; from locality TU 1250: Río Verde, Lower Pliocene part of Gurabo Formation. Right valve exterior. Length, 4.4 mm; height, 4.1 mm; width, 2.0 mm, × 4⅓.

16, 17. Hypotype. NMB G 14134; from locality NMB 16837: Río Cana, Upper Miocene Cercado Formation. Left valve: 16. exterior, × 4.7, 17. interior, × 6⅔. Length, 4.6 mm; height, 4.0 mm; width, 1.7 mm.

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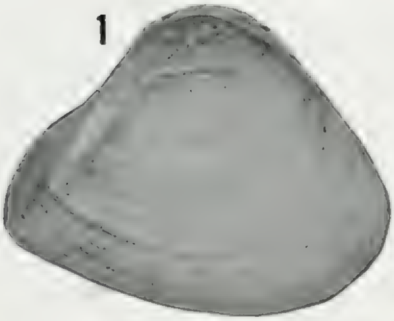

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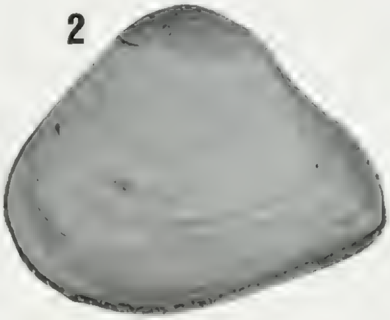

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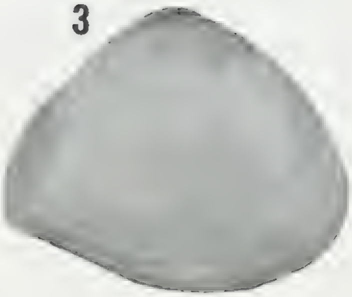

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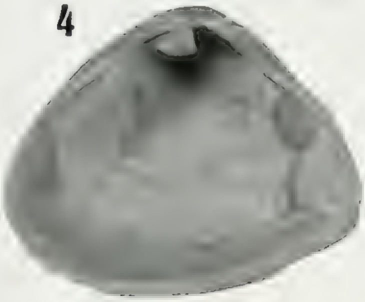

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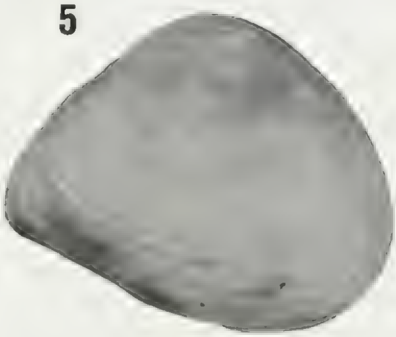

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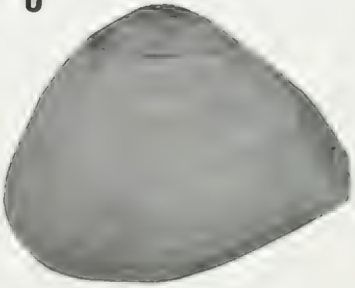

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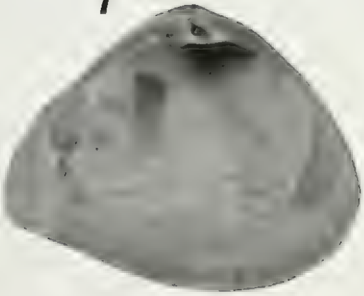

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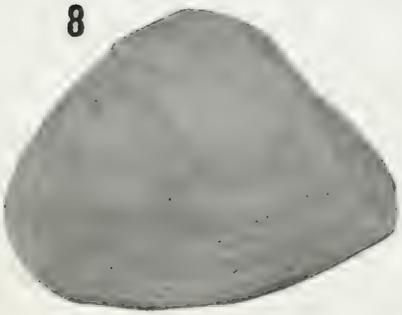

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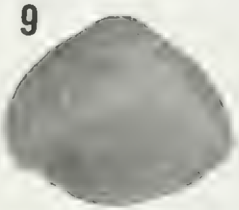

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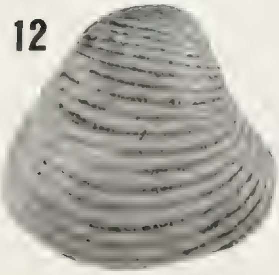
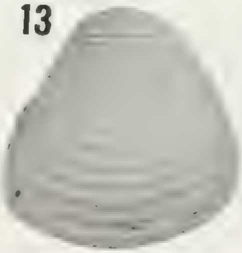
11

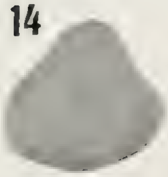
12



13

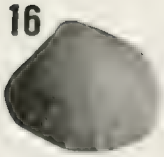


14



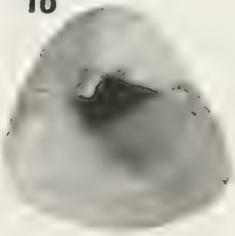
15

16



17

18



INDEX

Note: Page numbers are in light face; plate numbers are in **bold** face type; pages on which principal discussion occur are in *italics.*

Adams (1852a) 18,19
Adams (1852b) 17
aequalis,
  Corbula (*Panamicorbula*) 19
  Potamomya 18
aequivalvis,
  Corbula 17
  Corbula (*Juliacorbula*) 17,18
  Juliacorbula 17
aff. *C. inflata,*
  Corbula (*Panamicorbula*) 19
Agueguexquite Formation 11
Alabama 14
alabamiensis,
  Corbula 14
Allmon, Warren 6,16
Aloidis Mergerle von Mühlfeldt, 1811 12
Amphistegina Orbigny, 1826 26
Anadara Gray, 1847 26
  grandis (Broderip and Sowerby, 1829) 9
  patricia (Sowerby, 1850) 9,20,26
Anderson (1991) 11
Anderson (1994) 6,8–12,15,16,19,20
Angostura Formation 15
ANSP (Academy of Natural Sciences of Philadelphia,
    Philadelphia, PA, U.S.A.) 6,*11*,14,15,18,21
"*Arca*" beds 9,19

Baitoa Formation 5,10,14,15,17,22,26
Benamy, Elana 6
Bermont Formation 13
Blow, Warren 6
BMNH (Natural History Museum, London, U.K.) 6,*11*,13
Bold (1988) 9,26
Boss (1982) 12
Bowden Formation 5,11–14,17,22
Broderip and Sowerby (1829) 9
Brown and Pilsbry (1911) 17
Bruguière (1797) 12
Budd et al. (1996) 7,8

caimitica,
  Corbula (*Cuneocorbula*) 15,16
Caloosahatchee Formation 13
canae,
  Corbula (*Panamicorbula*) **3**,5,6,8,*19*,20
caribaea pergrata,
  Corbula (*Caryocorbula*) 16
Caribbean Sea 11
Caudites Coryell and Fields, 1937 26
Central America 5,12,17,19,22
cercadica,
  Corbula (*Caryocorbula*) 15
  Corbula (*Cuneocorbula*) 15,16
Cercado Formation 5,7,8,11,14,15,17–22,26
Chipola Formation 13
Claibornian Stage 14
contracta,
  Corbula 17
Corbulidae Lamarck, 1818 5,*12*
Corbulinae Lamarck, 1818 *12*
Corbula Bruguière, 1797 5,7,8,11,*12*
  aequivalvis Philippi, 1836 17
  alabamiensis Lea, 1833 14
  contracta Say, 1822 17
  cubaniana Orbigny, 1846 17
  disparilis Orbigny, 1846 20
  dominicensis Gabb, 1873b 14
  knoxiana Adams, 1852b 17
  knoxiana fossilis Pilsbry, 1922 17
  lavaleana Orbigny, 1846 15
  macdonaldi Dall, 1912 18
  sericea Dall, 1898 15
  sulcata Lamarck, 1801 12
  vieta Guppy, 1866a 20
  viminea Guppy, 1866b 12
Corbula (*Aloidis*) Megerle von Mühlfeldt, 1811
  vieta Guppy, 1866a 20
  sancti-dominici Maury, 1925 20
Corbula (*Bothrocorbula*) Gabb, 1873a 5,11,*12*
  radiatula Dall, 1898 13
  synarmostes Dall, 1898 13
  viminea Guppy, 1866b **1**,5,6,*7–14*,15,26
  wilcoxii Dall, 1898 13
Corbula (*Caryocorbula*) Gardner, 1926 5,11,*14*,17,20
  caribaea pergrata Maury, 1925 16
  cercadica Maury, 1917 15
  daphnis Maury, 1925 16
  democracia F. Hodson, 1931 15
  dominicensis Gabb, 1873b **1**,**2**,5,*14–15*
  dominicensis veracruzana Perrilliat, 1984 15
  helenae Maury, 1912 16
  manzanillensis Maury, 1925 17
  oropendula Olsson, 1922 17
  oropendula dolicha (Woodring, 1982) 17
  oropendula stena (Woodring, 1982) 17
  prenasuta Olsson, 1964 15
  sericea Dall, 1898 **2**,5,6,*7–11*,*15–17*,26
  smithiana Maury, 1912 16
Corbula (*Corbula*) Bruguière, 1797
  sericea Dall, 1898 15
  sulcata (Lamarck, 1801) 12
Corbula (*Cuneocorbula*) Cossmann, 1886 14
  caimitica Maury, 1917 15,16
  cercadica Maury, 1917 15,16
  cubaniana Orbigny, 1846 17
  dominicensis Gabb, 1873b 14
Corbula (*Hexacorbula*) Olsson, 1932 12
Corbula (*Juliacorbula*) Olsson and Harbison, 1953 5,11,*17*
  aequivalvis Philippi, 1836 17,18
  cubaniana Orbigny, 1846 17,18
  fossilis Pilsbry, 1922 **2**,5,7,8,*17–18*
  knoxiana Adams, 1852b 18
  scutata Gardner, 1943 18
Corbula (*Notocorbula*) Iredale, 1930 11,20
  vicaria (Iredale, 1930) 20
Corbula (*Panamicorbula*) Pilsbry, 1932 5,11,*18–19*,20
  aequalis (Adams, 1852a) 19
  aff. *C. inflata* (Adams, 1852a) 19
  canae n. sp. **3**,5–8,*19*,20

  inflata (Adams, 1852a) ... 19
  macdonaldi Dall, 1912 ... 19
  sp. ... **3**,*19–20*
  trigonalis (Adams, 1852a) ... 19
Corbula (*Serracorbula*) Olsson, 1961 ... 11
Corbula (*Tenuicorbula*) Olsson, 1932 ... 11
Corbula (*Varicorbula*) Grant and Gale, 1931 ... 5,11,*20*,21,22
  disparilis Orbigny, 1846 ... 21,22
  gibba (Olivi, 1792) ... 20
  heterogena Guppy (in Dall, 1898) ... 11,22
  operculata Philippi, 1848 ... 21
  philippii Smith, 1885 ... 21
  sanctianderaea Maury, 1925 ... 22
  sanctidominici Maury, 1925 ... **3**,5–8,11,*20–22*
  vieta Guppy, 1866a ... 20,21
  waltonensis Gardner, 1928 ... 22
Cossmann (1886) ... 14
Costa Rica ... 11,14,15,17,19,22
  Limón ... 15,16
  Limón Basin ... 5,11
  Punta Judas ... 11,19
cubaniana,
  Corbula ... 17
  Corbula (*Cuneocorbula*) ... 17
  Corbula (*Juliacorbula*) ... 17,18
Cytherella Jones, 1849 ... 26

Dall (1890–1903) ... 5,11,13–15,21,22
Dall (1912) ... 18,19
daphnis,
  Corbula (*Caryocorbula*) ... 16
democracia,
  Corbula (*Caryocorbula*) ... 15
disparilis,
Corbula ... 20
Corbula (*Varicorbula*) ... 21,22
Dominican Republic ... 5,6,11,12,14,15,17–22
  Cibao Valley ... 5,6
    Arroyo Bajón ... 14,17,22
    Arroyo Ballaco ... 22
    Arroyo López ... 17,22
    Cañada Zalaya ... 6,9,16,17,22,26
    Río Amina ... 6,13,14,16,17
    Río Cana ... 5–10,13–22,26
      Caimito ... 15,21
    Río Gurabo ... 6,8–11,13,14,16–18,22,26
    Río Mao ... 6,9–11,13,14,16,17,22,26
      Bluff 1 of Maury (1917) ... 17,22
      Bluff 2 of Maury (1917) ... 14,17,22
      Bluff 3 of Maury (1917) ... 14,17
    Río Verde ... 6,16,17,22
    Río Yaque del Norte ... 5,6,9–11,13–17,22,26
      Angostura ... 14,17
      López ... 9,14,22
      La Barranca ... 17,22
    Santiago ... 6,17,22
dominicensis,
  Corbula ... 14
  Corbula (*Caryocorbula*) ... **1**,**2**,5,*14–15*
  Corbula (*Cuneocorbula*) ... 14
dominicensis veracruzana,
  Corbula (*Caryocorbula*) ... 15

East Asia ... 14
eastern Pacific Ocean ... 5,9,11,17–20
  Panamic Province ... 11,18
Ecuador ... 15
Erycina Lamarck, 1805
  tensa Guppy, 1866a ... 21
Europe ... 20

Florida ... 5,11–13,17,18,22
fossilis,
  Corbula (*Juliacorbula*) ... **2**,5,*17–18*

Gabb (1873a) ... 11,12
Gabb (1873b) ... 5,14,15,17,20,21
Gabb (1881) ... 15
Gardner (1926) ... 11,12,14
Gardner (1928) ... 11,22
Gardner (1943) ... 18
Gatun Formation ... 5,11,15,17
Geological Society of America ... 6
gibba,
  Corbula (*Varicorbula*) ... 20
  Tellina ... 20
grandis,
  Anadara ... 9
Grant and Gale (1931) ... 11,20
Guppy (1866a) ... 21
Guppy (1866b) ... 5,12,13
Guppy (1876) ... 14
Guppy (in Dall, 1898) ... 11,22
Gurabo Formation ... 5,7,8,14,17,18,22,26

Haiti ... 6,14
helenae,
  Corbula (*Caryocorbula*) ... 16
heterogena,
  Corbula (*Varicorbula*) ... 11,22
Hodson and Hodson (1931) ... 15

IGM (Intituto de Geología, Ciudad Universitaria de México, D.F.,
    Mexico) ... *11*,18
inflata,
  Corbula (*Panamicorbula*) ... 19
  Potamomya ... 18
Iredale (1930) ... 11,20

Jamaica ... 5,11–14,17,22
Jeffery, Paul ... 6
Juliacorbula Olsson and Harbison, 1953
  aequivalvis (Philippi, 1836) ... 17
Jung (1969) ... 11,16–18,20
Jung (1986) ... 21
Jung, Peter ... 6

Keen (1971) ... 19,21
knoxiana fossilis,
  Corbula ... 17
knoxiana,
  Corbula ... 17
  Corbula (*Juliacorbula*) ... 18
Kool, Silvard ... 6
Krithe Brady, Crosskey, and Robertson, 1874 ... 26

l'Enfer Formation ... 11,18,19
  Courbaril Sand and Clay Member ... 18
Lamarck (1799) ... 12
Lamarck (1801) ... 12

Lamarck (1818) ... 12
Larkinia Reinhert, 1935 ... 26
Las Canobas Formation ... 14
lavaleana,
  Corbula ... 15
Lea (1833) ... 14
Lewy and Sambleton (1979) ... 12
Loxoconcha Sars, 1866 ... 26
Lyria Gray, 1847 ... 26

macdonaldi,
  Corbula ... 18
  Corbula (Panamicorbula) ... 19
Manzanilla Formation ... 11,17,21,22
manzanillensis,
  Corbula (Caryocorbula) ... 17
Mao Formation ... 5,7,8,14,17,26
  Mao Adentro Limestone Member ... 14
Maury (1912) ... 16
Maury (1917) ... 12–17,20,21
Maury (1922) ... 9
Maury (1925) ... 5,11,12,16–18,20–22
McLean (1951) ... 17
Mediterranean Sea ... 20
Megerle von Mühlfeldt (1811) ... 12
Melongena Schumacher, 1817 ... 26
Mexico ... 11,15,18
  Coatzacoalcos ... 11
  Veracruz ... 11,15,18
miliolid ... 26
Moín Formation ... 16,17
Moore (1969) ... 12,14,17,18,20
Museum of Comparative Zoology, Harvard University,
  Cambridge, MA, U.S.A. ... 6
Mytilus Linnaeus, 1758 ... 26

National Science Foundation ... 6
NMB (Naturhistorisches Museum, Basel, Switzerland) ... 6,*11*,13–22
North America ... 14,20

Oak Grove Formation ... 13
Oliva Bruguière, 1789 ... 26
Olivi (1792) ... 20
Olsson (1922) ... 11,12,17
Olsson (1932) ... 9,11,12
Olsson (1961) ... 9,11,17,18
Olsson (1964) ... 15
Olsson and Harbison (1953) ... 11,17
operculata,
  Corbula (Varicorbula) ... 21
Orbigny (1846) ... 17,21
oropendula,
  Corbula (Caryocorbula) ... 17
oropendula dolicha,
  Corbula (Caryocorbula) ... 17
oropendula stena,
  Corbula (Caryocorbula) ... 17

Pachycrommium ... 26
Paleontological Society ... 6
Panama ... 11,15,17,18,22
Paracytheridea Müller, 1894 ... 26
patricia,
  Anadara ... 9,20,26
Perrilliat (1984) ... 11,15,17,18
Peru ... 11,18
Philippi (1836) ... 17,18
Philippi (1848) ... 21
philippii,
  Corbula (Varicorbula) ... 21
Pilsbry (1922) ... 5,12,14,15,17,18,20,21
Pilsbry (1932) ... 11,18,19
Polystira Woodring, 1928 ... 26
Potamomya Sowerby, 1839
  aequalis Adams, 1852a ... 18
  inflata Adams, 1852a ... 18
  trigonalis Adams, 1852a ... 18
prenasuta,
  Corbula (Caryocorbula) ... 15
PRI (Paleontological Research Institution, Ithaca, NY, U.S.A.) ... 6,*11*,13,15,16,18,21
Proteoconcha Plusquellec and Sandberg, 1969 ... 26
pteropod ... 26

radiatula,
  Corbula (Bothrocorbula) ... 13
Radimella Pokorny, 1968 ... 26
Ramírez (1950) ... 12
Río Banano Formation ... 14
Rios (1975) ... 17
Rosenberg, Gary ... 6,14

sanctianderaea,
  Corbula (Varicorbula) ... 22
sancti-dominici,
  Corbula (*Aloidis*) ... 20
sanctidominici,
  Corbula (Varicorbula) ... **3**,5,6,8,11,*20*–22
Santa Rosa beds ... 11,15,18
Saunders et al. (1986) ... 5,6,9,11,14,15,17–20,22,26
Schmidt (1818) ... 12
Schneider, Jay ... 6
scutata,
  Corbula (Juliacorbula) ... 18
Senegal ... 12
sericea,
  Corbula ... 15
  Corbula (Caryocorbula) ... **2**,5,6,*7–11*,*15–17*,26
  Corbula (Corbula) ... 15
Seyfried et al. (1985) ... 11,19
Sigma Xi ... 6
Smith (1885) ... 21
smithiana,
  Corbula (Caryocorbula) ... 16
soritid ... 26
South America ... 14,17
Sowerby (1850) ... 9
Springvale Formation ... 11,18,19
  Melajo Clay Member ... 18
Stenzel et al. (1957) ... 20
Stewart (1930) ... 12
Stigmaulax Morch, 1852 ... 26
Strombina Morch, 1852 ... 26
Strombus Linnaeus, 1758 ... 26
sulcata,
  Corbula ... 12
  Corbula (Corbula) ... 12

synarmostes,
  Corbula (*Bothrocorbula*) 13

Talparo Formation 18
  Matura Sand and Clay Member 18
Taylor, Paul 6
Tellina Linnaeus, 1758 26
  gibba Olivi, 1792 20
tensa,
  Erycina 21
Thomonde Formation 14
Thompson, Jann 6
trigonalis,
  Corbula (*Panamicorbula*) 19
  Potamomya 18
Trinidad 5,11,16–19,21,22
TU (Tulane University, New Orleans, LA, U.S.A.) 6,*11*,13–17,21,22

USNM (United States National Museum of Natural History, Washington, DC, U.S.A.) 6,*11*,13,15,16,18,19,21
UW (Museum of Geology, University of Wisconsin-Madison, Madison, WI, U.S.A.) 6,*11*,16

Vaught (1989) 11
Venezuela 11,15
  Falcón 15
vicaria,
  Corbula (*Notocorbula*) 20
vieta,
  Corbula 20
  Corbula (*Aloidis*) 20
  Corbula (*Varicorbula*) 20,21
viminea,
  Corbula 12
  Corbula (*Bothrocorbula*) **1**,5,6,*8–14*,15,26
Vokes, E. (1989) 11
Vokes, H. (1945) 12,18,19
Vokes, H. (1980) 12
Vokes, H. (1989) 13,15
Vokes, Emily 6

Waller, Thomas 6
waltonensis,
  Corbula (*Varicorbula*) 22
Weisbord (1964) 17,20,21
West Indies 12,17
western Atlantic Ocean 11,21
western Pacific Ocean 20
Westphal, Klaus 6
wilcoxii,
  Corbula (*Bothrocorbula*) 13
Woodring (1925) 12–15
Woodring (1973) 9
Woodring (1982) 11,17,20–22
Woodring et al. (1924) 14

Yonge (1946) 20

Zone H of Maury (1917) 15

NEOGENE PALEONTOLOGY IN THE NORTHERN DOMINICAN REPUBLIC. 17. THE FAMILIES CUSPIDARIIDAE AND VERTICORDIIDAE (MOLLUSCA: BIVALVIA)

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ABSTRACT

Seven species belonging to two genera of Cuspidariidae and two genera of Verticordiidae are described and figured. Five of them occur in the Neogene sections of the Dominican Republic and their stratigraphic occurrences are given. Two species of the verticordiid genus *Trigonulina* are known from the Recent fauna only: one from the Western Atlantic, the other from the Eastern Pacific. The latter is described as new (*T. pacifica* n. sp.). The two living species are discussed herein for comparative purposes. Out of the five fossil species, only two are well represented (*Cardiomya islahispaniolae* and *Trigonulina bowdenensis*). The remaining three species are known from very few specimens.

RESUMEN

Se describen siete especies pertenecientes a dos géneros de la familia Cuspidariidae y a dos géneros de la familia Verticordiidae. Cinco de ellas se encuentran representadas en las secciones del Neogeno de la República Dominicana; se indican sus ámbitos estratigráficos. Dos especies de verticordidos del género *Trigonulina* solamente se conocen de la fauna actual. *T. pacifica* habita en el Pacífico Oriental y se describe aqui por primera vez; la otra habita en el Atlántico Occidental. Ambas se mencionan con propósitos comparativos. De las cinco especies fósiles, apenas dos estan bien representadas (*Cardiomya islahispaniolae* y *Trigonulina bowdenensis*). El material existente de las restantes tres especies es muy escaso.

INTRODUCTION

This paper is a further contribution to the series of taxonomic studies dealing with Neogene fossils from sections situated in the Cibao Valley of the northern Dominican Republic (Text-fig. 1). The project and the framework within which these studies are being carried out have been outlined by Saunders *et al.* (1982) and Saunders *et al.* (1986). Jung (1986, p. 5) listed the most important early collections of molluscs from this area. The material of Cuspidariidae and Verticordiidae available for this paper is not rich. I nevertheless thought it worthwhile studying these two families especially considering the facts that (1) illustrations of these groups in literature are generally rather poor, and (2) the method of scanning electron microscopy allows to produce good illustrations.

As is the case for all the contributions to this series, the material studied has been collected from measured sections. The geographic location of the investigated areas is shown in Text-figure 1. For detailed information as to geographic locations and stratigraphic position of all the collecting stations, as well as to the general biostratigraphic framework and the ages, the reader is referred to the paper by Saunders *et al.* (1986). Formational names have been used with care, because correlations of the sections are not certain.

ACKNOWLEDGMENTS

The material on which this paper is based was collected during field work carried out in the years 1978, 1979, and 1980 as part of the project referred to above. The field work was made possible by a grant from the Swiss National Science Foundation (Grant 2.646-0.76). The financial help and the assistance in the field provided by Institut Français du Pétrole are gratefully acknowledged.

I am indebted to the following persons for the loan of specimens under their care: Gary Rosenberg, Academy of Natural Sciences, Philadelphia, PA, U.S.A.; Alan Kabat, Mark Florence, Jann Thompson, Warren Blow, all of the National Museum of Natural History, Washington, DC, U.S.A.; Kathie Way, The Natural History Museum, London, England; James McLean, Los Angeles County Museum, Los Angeles, CA, U.S.A.

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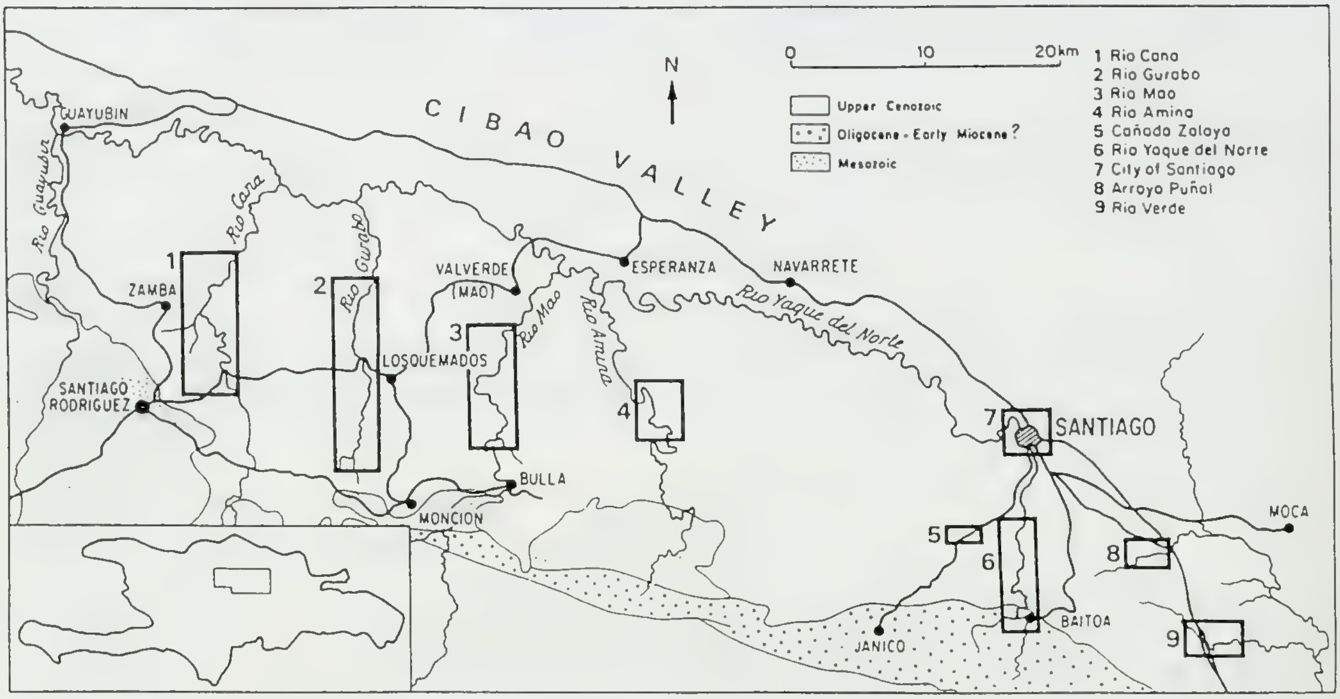
BIOSTRATIGRAPHY AND PALEOBIOGEOGRAPHY

A total of seven species belonging to two genera of Cuspidariidae and two genera of Verticordiidae is discussed in this paper. Two species of the verticordiid genus *Trigonulina* are known from the recent fauna


N
0
10
20km
1 Rio Cana
2 Rio Gurabo
3 Rio Mao
4 Rio Amina
5 Cañada Zalaya
6 Rio Yaque del Norte
7 City of Santiago
8 Arroyo Puñal
9 Rio Verde
Upper Cenozoic
Oligocene - Early Miocene ?
Mesozoic
CIBAO VALLEY
GUAYUBIN
Rio Guayubin
Rio Cana
Rio Gurabo
ZAMBA
SANTIAGO RODRIGUEZ
VALVERDE (MAO)
LOSQUEMADOS
Rio Mao
Rio Amina
ESPERANZA
NAVARRETE
Rio Yaque del Norte
SANTIAGO
BULLA
MONCION
MOCA
BAITOA
JANICO
1
2
3
4
5
6
7
8
9

Text-figure 1.—Index map showing location of investigated areas in the Cibao Valley, Dominican Republic (after Jung, 1986, Text-fig. 1).

only, one from the Western Atlantic, the other from the Eastern Pacific. They have been included here for comparative purposes.

The stratigraphic occurrences of the remaining five species are plotted in Text-figures 2–7. The species are not continuously present through a given sequence of sediments, but their occurrences are spotty (Jung and Petit, 1990, p. 88; Jung, 1994, p. 6). The five species occur in the following sections:

Río Gurabo section (Text-figs. 2, 3):

Cardiomya islahispaniolae (Maury, 1917)
Cardiomya distira (Dall, 1903)
Haliris jamaicensis (Dall, 1903)
Trigonulina bowdenensis (Dall, 1903)

Río Cana section (Text-fig. 4):

Cardiomya islahispaniolae (Maury, 1917)
Plectodon granulatus (Dall, 1881)
Trigonulina bowdenensis (Dall, 1903)

Río Mao section (Text-figs. 5–7):

Cardiomya islahispaniolae (Maury, 1917)

Arroyo Zalaya:

Cardiomya distira (Dall, 1903)
Haliris jamaicensis (Dall, 1903)

Arroyo Babosico near La Barranca, Río Yaque del Norte:

Cardiomya distira (Dall, 1903)

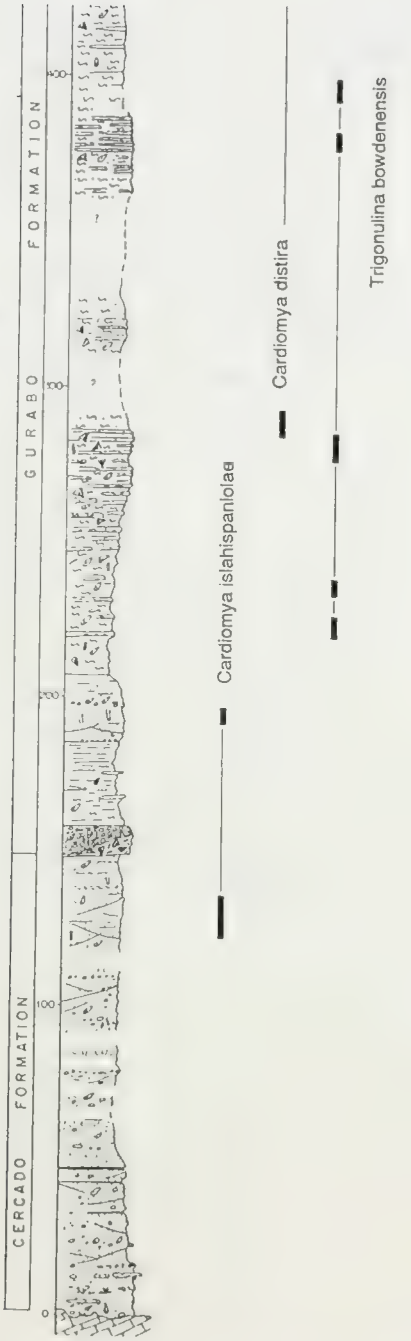
Río Verde:

Trigonulina bowdenensis

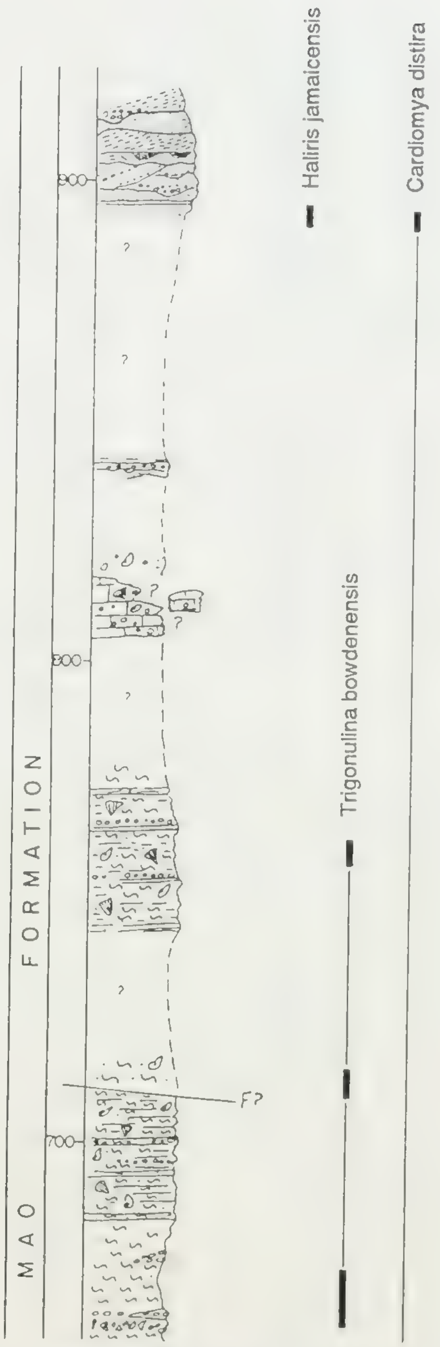
As can be seen from the above lists *Cardiomya islahispaniolae* occurs in the sections of Río Gurabo, Río Cana, and Río Mao. *Trigonulina bowdenensis* has been found in the sections of Río Gurabo, Río Cana, and Río Verde. *Cardiomya distira* is recorded from the sections of Río Gurabo, Arroyo Zalaya, and Arroyo Babosico; *Haliris jamaicensis* from the sections of Río Gurabo and Arroyo Zalaya, whereas *Plectodon granulatus* is restricted to the Río Cana section.

The representation of these five species in the various sections is rather uneven. Four species occur in the Río Gurabo section, three in the Río Cana section, two in Arroyo Zalaya, and a single species in the sections of Río Mao, Arroyo Babosico, and Río Verde.

The numerical representation of the five species in the Dominican deposits is uneven as well. *Trigonulina bowdenensis* is represented by 80, *Cardiomya islahispaniolae* by 52 Dominican specimens. On the other hand *Cardiomya distira* is represented by only eight, *Haliris jamaicensis* by three, and *Plectodon granulatus* by a single specimen. The three latter species therefore are very rare.


CERCADO FORMATION
GURABO FORMATION
0
100
200
300
400
Cardiomya islahispaniolae
Cardiomya distira
Trigonulina bowdenensis

Text-figure 2.—Columnar section of Río Gurabo showing occurrences of species dealt with herein (after Saunders *et al.*, 1986, Text-fig. 6). Numbers in second column from left refer to thickness in m.

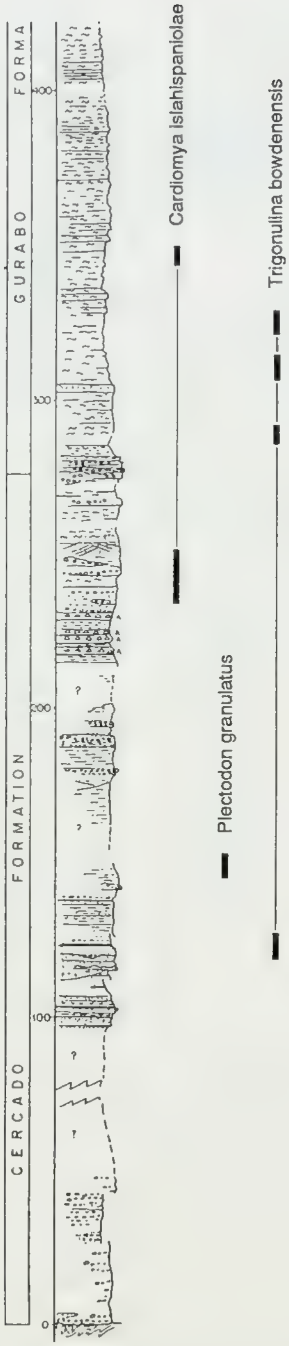

MAO FORMATION
700
800
900
F?
Haliris jamaicensis
Cardiomya distira
Trigonulina bowdenensis

Text-figure 3.—Río Gurabo: upper part of columnar section showing occurrences of species dealt with herein (after Saunders *et al.*, 1986, Text-fig. 6). Numbers in second column from left refer to thickness in m.

Of the five species mentioned above, only *Cardiomya islahispaniolae* is endemic to the Neogene of the Dominican Republic, Three species, namely *Cardiomya distira, Haliris jamaicensis,* and *Trigonulina bowdenensis,* also occur in the early Pliocene Bowden Formation of Jamaica, and *Plectodon granulatus* is known from the middle Miocene Shoal River Formation of Florida, the Pliocene of Florida, and from the Recent fauna of the Western Atlantic.

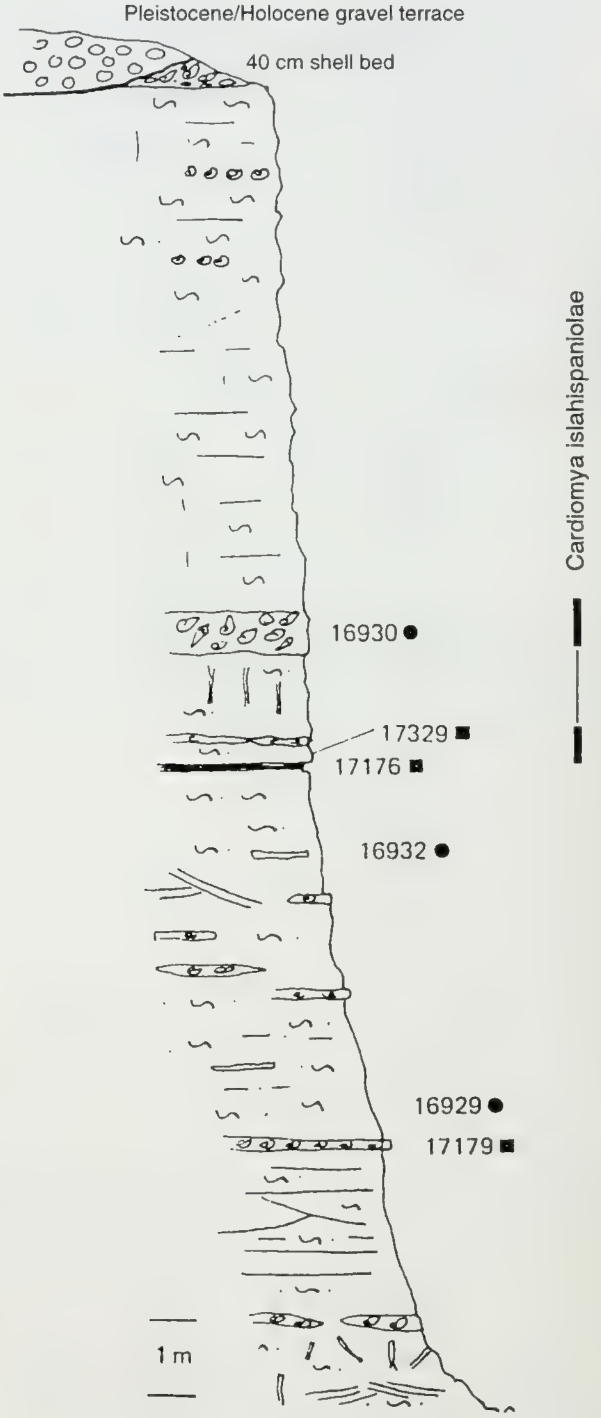
ABBREVIATIONS OF REPOSITORY INSTITUTIONS

ANSP: Academy of Natural Sciences, Philadelphia, PA, U.S.A.

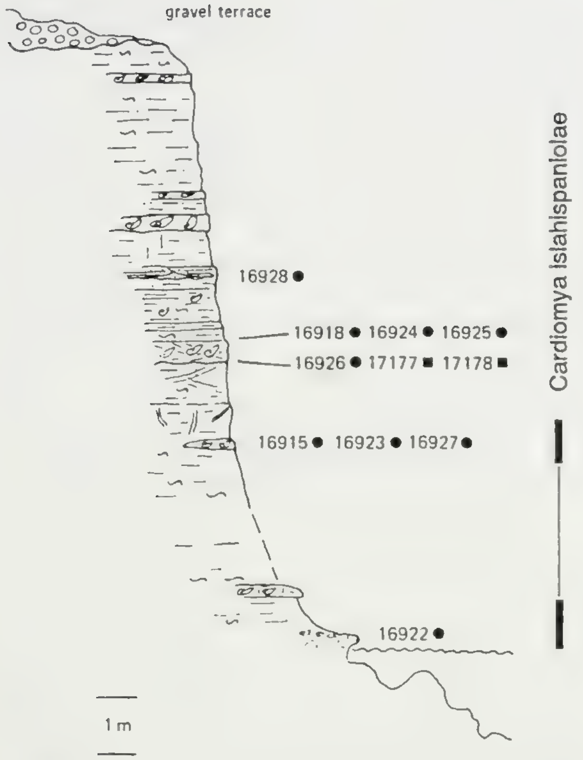

GURABO FORMA
CERCADO FORMATION
Cardiomya islahispaniolae
Trigonulina bowdenensis
Plectodon granulatus
400
300
200
100
0

Text-figure 4.—Columnar section of Río Cana showing occurrences of species dealt with herein (after Saunders *et al.*, 1986, Text-fig. 16). Numbers in second column from left refer to thickness in m.

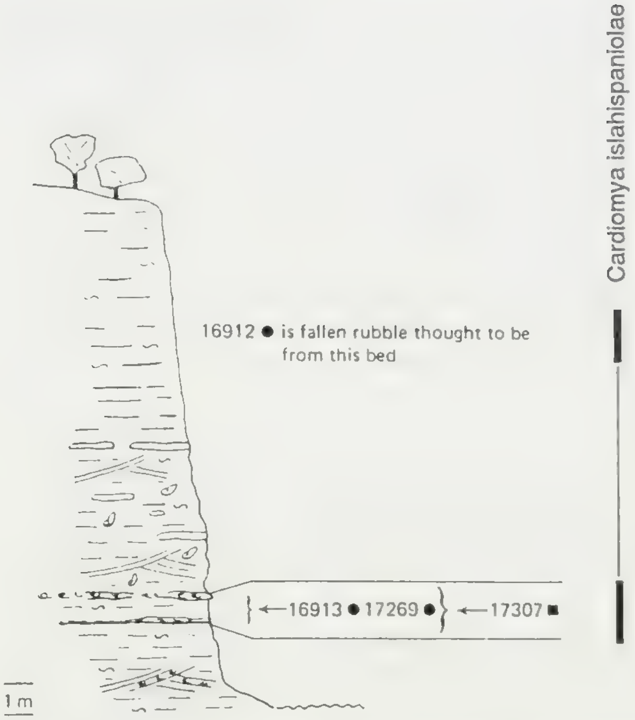
BMNH: British Museum (Natural History), London, England, now The Natural History Museum, London.
LACM: Los Angeles County Museum of Natural History, Los Angeles, CA, U.S.A.
NMB: Naturhistorisches Museum Basel, Switzer-


Pleistocene/Holocene gravel terrace
40 cm shell bed
Cardiomya islahispaniolae
16930
17329
17176
16932
16929
17179
1 m

Text-figure 5.—Section exposed in Maury's Bluff 2 on Río Mao showing occurrence of *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917) and stratigraphic positions of NMB localities: black squares represent localities collected for microfossils and lithologic analyses; black circles represent localities collected for macrofossils (after Saunders *et al.*, 1986, Text-fig. 31).



Text-figure 6.—Section exposed at mouth of Arroyo Bajón on Río Mao showing occurrence of *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917) and stratigraphic positions of NMB localities: black squares represent localities collected for microfossils and lithologic analyses; black circles represent localities collected for macrofossils (after Saunders *et al.*, 1986, Text-fig. 32).


16912 ● is fallen rubble thought to be from this bed
16913 ● 17269 ●
17307 ■
1 m
Cardiomya islahispaniolae

Text-figure 7.—Section exposed at the downstream (eastern) end of Maury's Bluff 3 on Río Mao showing occurrence of *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917) and stratigraphic positions of NMB localities: black square represents a locality collected for microfossils and lithologic analyses; black circles represent localities collected for macrofossils (after Saunders *et al.*, 1986, Text-fig. 33).

	land (the letter G after NMB stands for bivalves).
PRI:	Paleontological Research Institution, Ithaca, NY, U.S.A.
TU:	Tulane University, New Orleans, LA, U.S.A.
USNM:	United States National Museum of Natural History, Smithsonian Institution, Washington, DC, U.S.A.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

The basis for the preparation of this paper has been the combined collections of the Naturhistorisches Museum Basel and Tulane University. All of the figured specimens of Cuspidariidae and Verticordiidae derived from these collections are deposited in the Naturhistorisches Museum Basel. It was originally planned to examine and refigure the type specimens of all the species of Cuspidariidae and Verticordiidae occurring in the Dominican Republic Neogene as well as the type specimens of species which were most important for comparative purposes.

However, this plan has not been carried out for various reasons. As mentioned below under *Cardiomya islahispaniolae,* the holotype of that species is badly broken (Fast, 1978, p. 80) and therefore could not be refigured. In addition the type specimens of four species of Cuspidariidae and Verticordiidae described by Dall (1903) from the early Pliocene Bowden Formation of Jamaica have been available to me: *Cardiomya craspedonia,* which does not occur in the Dominican Republic, and *Cardiomya distira, Haliris jamaicensis,* and *Trigonulina bowdenensis,* which occur in the Dominican Republic as well. The type lots of all these four species consist of three specimens each. All those specimens are glued to a piece of black paper. I tried to remove the specimens from the black paper using various chemicals in an attempt to dissolve the glue but without success. Lectotypes of all four species have been selected, but they are not refigured herein.

Although the amount of material available for this study is mentioned under each species, a summary of the number of lots and specimens of each species is given in Table 1.

As mentioned above, three of the species discussed herein are also known from the Bowden Formation of

Table 1.—Numbers of lots and specimens of each of the seven species of Cuspidariidae and Verticordiidae dealt with in this paper.

taxon	*number of lots*	*number of specimens*
Cardiomya (Cardiomya) islahispaniolae	20	50
Cardiomya (Bowdenia) distira	8	47
Plectodon granulatus	11	22
Haliris jamaicensis	4	10
Trigonulina ornata	6	1049
Trigonulina pacifica	23	1840
Trigonulina bowdenensis	32	112
Total	104	3130

Table 2.—Number of specimens available from the Neogene of the Dominican Republic and from the Bowden Formation of Jamaica.

species	*specimens from Dominican Republic*	*specimens from Bowden, Jamaica*
Cardiomya islahispaniolae	50	0
Cardiomya distira	8	39
Plectodon granulatus	1	0
Haliris jamaicensis	3	7
Trigonulina bowdenensis	80	32

Jamaica, but their numerical representation differs greatly from that in the Dominican Republic. Table 2 gives the number of specimens of the five fossil species available from the Dominican Republic and from Bowden, Jamaica.

A short discussion of species concepts has been given by Jung (1986, p. 9; 1989, p. 37), and definitions of the headings used in the following systematic part may be found in Jung (1989, p. 35) and in Jung and Petit (1990, p. 93). They are not repeated here.

SYSTEMATICS

Family **CUSPIDARIIDAE** Dall, 1886

Genus **CARDIOMYA** A. Adams, 1864

Cardiomya A. Adams, 1864, p. 208

Type species (by monotypy).—Neaera gouldiana Hinds, 1843. Recent, seas of Japan.

Diagnosis.—Shell of small to medium size, rostrate. Sculpture consisting of radial ribs. Radial sculpture often restricted to main shell disc or continuing over the rostrum as well. There may be secondary radial ribs. Left hinge with a subumbonal chondrophore but no teeth. Right hinge with a subumbonal chondrophore and one or two lateral teeth. Posterior lateral tooth usually prominent.

Remarks.—*Cardiomya* not only includes Neogene, Pleistocene (Grant and Gale, 1931), and Recent species but also a number of species from deposits of Eocene and Oligocene age (Durham, 1944; Gardner, 1945; Harris, 1919; Meyer and Aldrich, 1886; Turner, 1938; Vokes, 1939). According to the Treatise on Invertebrate Paleontology (p. N854) the oldest record dates back to the late Cretaceous. The stratigraphic range of *Cardiomya* is therefore late Cretaceous to Recent.

Subgenus **CARDIOMYA** sensu stricto

Cardiomya (Cardiomya) islahispaniolae
(Maury, 1917)
Plate 1, figures 1–6; Plate 2, figures 1–4;
Text-figure 8

Neaera alternata d'Orbigny. Gabb, 1873, p. 248.
Neaera ornatissima d'Orbigny. Gabb, 1873, p. 248; Guppy, 1876, p. 530.
Cuspidaria islahispaniolae Maury, 1917, p. 196, pl. 26, fig. 20.
Cuspidaria ornatior Pilsbry and Johnson, 1917, p. 195; Pilsbry, 1922, p. 414, pl. 38, figs. 11, 12.
Cuspidaria gabbi Pilsbry and Johnson, 1917, p. 195; Pilsbry, 1922, p. 415, pl. 38, fig. 10.

Description.—Shell of medium size (up to 9 mm in length), delicate, rostrate. Umbos prosogyrate, placed almost centrally. Sculpture consisting of numerous radial ribs. Posteriormost rib more prominent than the others, forming a small carina marking the boundary between main shell disc and rostrum. In addition to this small carina there may be one or more ribs just anterior to it which are more prominent than all the other ribs on the main shell disc and have wider interspaces. There may be a few secondary radial ribs. Except for the more prominent posterior ribs the radial ribs are usually well developed only on the ventral part of the main shell disc. Dorsal part of the main shell disc is smooth or sculptured by concentric growth lines. The rostrum is smooth or sculptured by growth lines. There may be an indication of a radial rib near its postero-dorsal margin, where the growth lines are coarser and more prominent. Left hinge with a subumbonal chondrophore but no teeth; margin bent in a dorsal direction anteriorly and posteriorly. Right hinge with a subumbonal chondrophore and a prominent posterior lateral tooth; antero-dorsal margin bent slightly upwards.

Holotype of C. islahispaniolae.—PRI 28904. This is a right valve which is badly broken according to Fast (1978, p. 80) and Warren Allmon (written communication, September 22, 1993).

Dimensions of holotype of C. islahispaniolae.—Length 9 mm; height 6 mm (Maury, 1917, p. 196).

Type locality of C. islahispaniolae.—Bluff 3 of Maury on Río Mao, Dominican Republic. Cercado Formation (late Miocene). This includes NMB localities 16912, 16913, 17269, and 17307 (Saunders *et al.* 1986, text-figs. 29, 33).

Holotype of C. ornatior.—ANSP 2790. This is the specimen (a left valve) figured by Pilsbry (1922, pl. 38, fig. 12).

Dimensions of holotype of C. ornatior.—Length 5.0 mm; height 2.9 mm.

Type locality of C. ornatior.—"Santo Domingo". No further details are available.

Paratype of C. ornatior.—ANSP 79015. This is the specimen (a left valve) figured by Pilsbry (1922, pl. 38, fig. 11).

Dimensions of paratype of C. ornatior.—Length 4.8 mm; height 2.7 mm.

Holotype of C. gabbi.—ANSP 2791. This is the specimen (a left valve) figured by Pilsbry (1922, pl. 38, fig. 10).

Dimensions of holotype of C. gabbi.—Length 8.0 mm; height 5.3 mm.

Type locality of C. gabbi.—"Santo Domingo". No further details are available.

Paratype of C. gabbi.—ANSP 79016.

Dimensions of paratype of C. gabbi.—Length 7.4 mm; height 5.2 mm.

Remarks.—The 40 available specimens (some of which are incomplete) show variability in rostrum shape and radial sculpture. The rostrum may be relatively long and narrow, or it may be shorter, thus giving the impression of greater width. In some specimens only the posteriormost radial rib is more prominent than the others. In other specimens there may be up to four more prominent radial ribs with wider interspaces. This variability of the radial sculpture obviously has been the reason for the introduction of the names *ornatior* and *gabbi* by Pilsbry and Johnson (1917, p. 195).

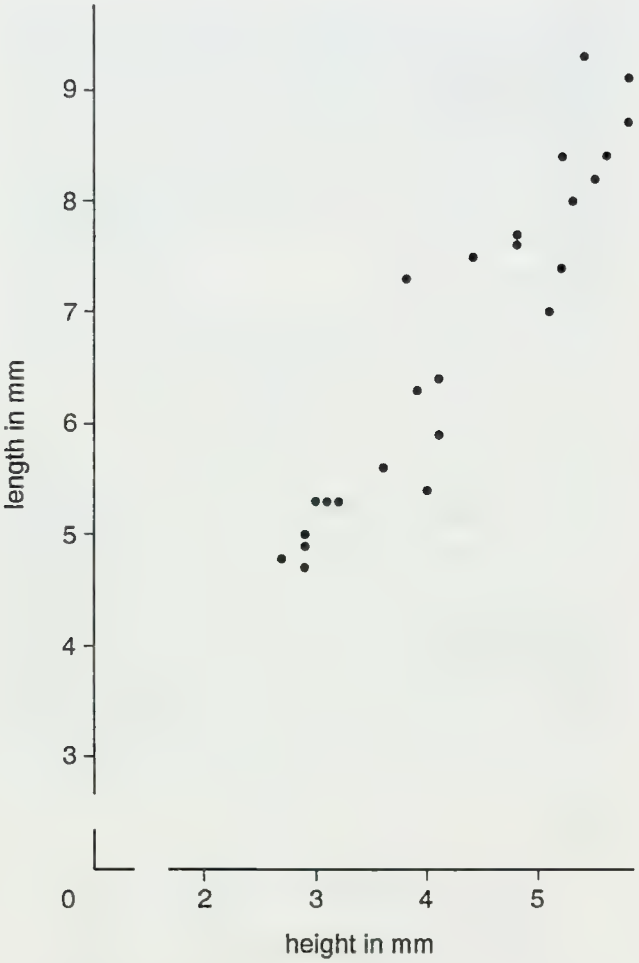
As mentioned in the introduction to the systematic paleontology, the type specimens of four species of Cuspidariidae and Verticordiidae described by Dall (1903) from the early Pliocene Bowden Formation of Jamaica are available. Three of them occur in the Dominican Republic as well: *Cardiomya* (*Bowdenia*) *distira*, *Haliris jamaicensis*, and *Trigonulina bowdenensis*. For each of these species a lectotype has been selected (see under those species). The same is done for the fourth species, *Cardiomya* (*Cardiomya*) *craspedonia*, which does not occur in the Dominican Republic but is compared with *C. islahispaniolae*. As is the case for the other three species the type lot of *C. craspedonia* consists of three specimens, which had been glued to a piece of black paper and cannot be removed from it without risk of damage. The type specimens of *C. craspedonia* (all left valves) are:

1. Lectotype: USNM 135691. Length 4.5 mm; height 2.7 mm. This is the specimen figured by Dall (1903, pl. 57, fig. 17) and Woodring (1925, pl. 10, fig. 20).
2. Paralectotype: USNM 482409. Length 3.6 mm; height 2.3 mm. This is the specimen figured by Woodring (1925, pl. 10, fig. 22).
3. Paralectotype: USNM 482410. Length 4.3 mm; height 2.8 mm. This is the specimen figured by Woodring (1925, pl. 10, fig. 21).

Comparisons.—*C. islahispaniolae* is similar but nevertheless clearly distinct from *C. craspedonia* Dall (1903, p. 1506, pl. 57, fig. 17) from the early Pliocene Bowden Formation of Bowden, Jamaica. It is not only considerably larger (practically twice as large) than *C. craspedonia*, but *C. craspedonia* has more numerous secondary radial ribs on the main shell disc. In addition the rostrum of *C. craspedonia* is proportionately shorter.

Material.—20 lots with a total of 50 specimens as listed below:

1. 1 spec., ANSP 2790: holotype of *C. ornatior*; "Santo Domingo".
2. 1 spec., ANSP 79015: paratype of *C. ornatior*; "Santo Domingo".
3. 1 spec., ANSP 2791: holotype of *C. gabbi*; "Santo Domingo".
4. 1 spec., ANSP 79016: paratype of *C. gabbi*; "Santo Domingo".
5. 1 spec., NMB locality 16912: Río Mao, Bluff 3 of Maury; Cercado Formation (late Miocene).
6. 4 spec., NMB locality 16913: Río Mao, Bluff 3 of Maury; Cercado Formation (late Miocene).
7. 2 spec., NMB locality 16915: Río Mao, Arroyo Bajón; Cercado Formation (late Miocene).
8. 1 spec., NMB locality 16917: Río Mao, Arroyo Bajón; Cercado Formation (late Miocene).
9. 1 spec., NMB locality 16922: Río Mao, Arroyo Bajón; Cercado Formation (late Miocene).
10. 1 spec., NMB locality 16923: Río Mao, Arroyo Bajón; Cercado Formation (late Miocene).
11. 2 spec., NMB locality 16929: Río Mao; Cercado Formation (late Miocene).
12. 1 spec., NMB locality 16930: Río Mao, Bluff 2 of Maury; Cercado Formation (late Miocene).
13. 1 spec., NMB locality 15878: Río Gurabo; lower part of Gurabo Formation (late Miocene).



Text-figure 8.—Length/height diagram of *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917).

14. 5 spec., NMB locality 15903: Río Gurabo; upper part of Cercado Formation (late Miocene).
15. 1 spec., NMB locality 15906: Río Gurabo; uppermost part of Cercado Formation (late Miocene).
16. 3 spec., NMB locality 15907: Río Gurabo; uppermost part of Cercado Formation (late Miocene).
17. 2 spec., NMB locality 16817: Río Cana, Cañada de Zamba; lower part of Gurabo Formation (early Pliocene).
18. 12 spec., NMB locality 16837: Río Cana; uppermost part of Cercado Formation (late Miocene).
19. 1 spec., NMB locality 16838: Río Cana; uppermost part of Cercado Formation (late Miocene).
20. 10 spec., TU locality 1294 (= NMB locality 18556): Río Mao, Bluff 3 of Maury; Cercado Formation (late Miocene).

Measurements.—Plotted in Text-figure 8.

Occurrence.—This species is recorded from the following areas: Río Mao: Cercado Formation (late Miocene): NMB localities 16912, 16913, TU locality 1294 (= Bluff 3 of Maury); 16915, 16917, 16922, 16923 (all Arroyo Bajón); 16929, 16930 (= Bluff 2 of Maury) (Saunders *et al.*, 1986, text-figs. 29, 30, table 3). Río Gurabo; lower part of Gurabo Formation (late Miocene): NMB locality 15878. Upper part of Cercado Formation (late Miocene): NMB localities 15903, 15906, 15907 (Saunders *et al.*, 1986, text-figs. 4, 6).

Río Cana; lower part of Gurabo Formation (early Pliocene): NMB locality 16817. Uppermost part of Cercado Formation (late Miocene): NMB localities 16837, 16838 (Saunders *et al.*, 1986, text-figs. 15, 16).

Distribution.—Not known from outside the Dominican Republic.

Subgenus **BOWDENIA** Dall, 1903

Bowdenia Dall, 1903, p. 1504.

Type species (*by original designation and monotypy*).—*Cuspidaria* (*Bowdenia*) *distira* Dall. Bowden, Jamaica. Bowden Formation (Pliocene).

Diagnosis.—Shell small (around 3 mm in length), rostrate. Umbos prosogyrate, almost centrally placed. Sculpture of fine, more or less well developed radial ribs. Rostrum well set off from main shell disc by a more prominent radial rib. Ventral margin of main shell disc evenly rounded. Hinge of left valve consisting of an inconspicuous posterior lateral tooth situated just behind a cavity to receive the posterior cardinal tooth of the right valve, which in turn is situated behind the subumbonal chondrophore. Hinge of right valve consisting of a subumbonal chondrophore, a weakly developed anterior cardinal tooth, and a prominent posterior cardinal tooth. Postero-dorsal margin of left valve somewhat thickened to fit the groove of the postero-dorsal margin of the right valve.

Remarks.—So far the type species of *Bowdenia, B. distira* Dall, is the only species assigned to this subgenus. *Bowdenia* is therefore known only from the Pliocene Bowden Formation of Bowden, Jamaica, and the late Miocene part of the Gurabo Formation, Dominican Republic (see below).

Cardiomya (Bowdenia) distira (Dall, 1903)
Plate 3, figures 1–5; Plate 4, figures 1–5;
Text-figure 9

Cuspidaria (*Bowdenia*) *distira* Dall, 1903, p. 1506, pl. 57, fig. 16; Woodring, 1925, p. 91, pl. 11, figs. 1–5.

Description.—Shell small (around 3 mm in length), delicate, rostrate. Umbos prosogyrate, placed almost centrally. Sculpture consisting of fine radial ribs, which may be fairly well developed, but sometimes hardly recognizable. Rostrum well set off from main shell disc by a more prominent radial rib. The concave part of the rostrum of the left valve sometimes carrying a few fine radial riblets, but corresponding area of right valve does not. Concave part of rostrum adjoining postero-dorsal margin carrying three or four ribs. Ventral margin of main shell disc evenly rounded. Growth lines usually more clearly developed on right valve. Hinge of left valve consisting of an inconspicuous posterior lateral tooth behind a cavity to receive the posterior cardinal tooth of right valve. This cavity is situated behind the subumbonal chondrophore. Hinge of right valve consisting of a subumbonal chondrophore, a weakly developed anterior cardinal tooth, and a prominent posterior cardinal tooth. Postero-dorsal margin of left valve somewhat thickened to fit groove of postero-dorsal margin of right valve.

Lectotype (selected herein).—USNM 135692. This is the specimen figured by Dall (1903, pl. 57, fig. 16) and Woodring (1925, pl. 11, fig. 1), a left valve.

Dimensions of lectotype.—Length 3.3 mm; height 2.5 mm.

Type locality.—Bowden, Jamaica. Bowden Formation (early Pliocene).

Paralectotype.—USNM 482411. This is the specimen figured by Woodring (1925, pl. 11, figs. 2, 3), a left valve.

Dimensions of paralectotype USNM 482411.—Length 3.1 mm; height 2.3 mm.

Paralectotype.—USNM 482412. This is the specimen figured by Woodring (1925, pl. 11, figs. 4, 5), a right valve.

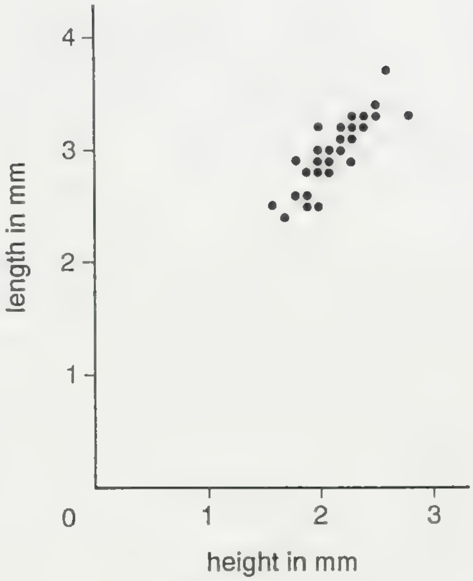
Dimensions of paralectotype USNM 482412.—Length 3.0 mm; height 2.0 mm.

Remarks.—The type lot of this species consists of the lectotype and the two paralectotypes. All three specimens are glued to a piece of black paper. Originally I intended to remove the specimens from the black paper in order to refigure the exterior of the lectotype and to figure its interior. Various chemicals have been used in an attempt to dissolve the glue but without success. The lectotype is therefore not refigured. Instead several topotypes are figured (Pl. 3, fig. 5; Pl. 4, figs. 1–5).

The Dominican Neogene has yielded eight specimens of this species. As hinted at in the above description there is some variability in the development of the radial ribs. They may be stronger or weaker. Sometimes they are evenly developed over the entire main shell disc, sometimes they are restricted to the ventral part of the main shell disc.

Comparisons.—As *Cardiomya (Bowdenia) distira* is the only species of the subgenus known no comparisons can be made.

Material.—Eight lots with a total of 47 specimens as listed below:



Text-figure 9.—Length/height diagram of *Cardiomya (Bowdenia) distira* (Dall, 1903).

1. 3 spec., USNM 135692 (lectotype) and two paralectotypes (USNM 482411, 482412). Bowden, Jamaica. Bowden Formation (early Pliocene).
2. 1 spec., NMB locality 15846: Río Gurabo, Dominican Republic. Latest Miocene part of Gurabo Formation (Pl. 3, figs. 1–4).
3. 5 spec., TU locality 1227A (= NMB locality 18582): Arroyo Zalaya, Dominican Republic; *Globorotalia margaritae* zone (early Pliocene).
4. 1 spec., TU locality 1352 (= NMB locality 18584): Río Gurabo, Dominican Republic; middle Pliocene part of Mao Formation.
5. 1 spec., TU locality 1403 (= NMB locality 18586): Arroyo Babosico near Río Yaque del Norte at La Barranca; upper part of *Globorotalia margaritae* zone (late early Pliocene).
6. 33 spec., NMB locality 10635: Bowden, Jamaica. Bowden Formation (early Pliocene).
7. 1 spec., NMB locality 11146: Bowden, Jamaica. Bowden Formation (early Pliocene).
8. 2 spec., NMB locality 17617: Bowden, Jamaica. Bowden Formation (early Pliocene).

Measurements.—Plotted in Text-figure 9.

Occurrence.—Río Gurabo section: latest Miocene part of Gurabo Formation: NMB locality 15846 (Saunders *et al.*, 1986, text-figs. 4, 6); middle Pliocene part of Mao Formation: TU locality 1352. *Globorotalia margaritae* zone (early Pliocene) of Arroyo Zalaya (TU locality 1227A) and Arroyo Babosico (TU locality 1403).

Distribution.—Bowden Formation (early Pliocene) of Bowden, Jamaica. Latest Miocene part of Gurabo

Formation; *Globorotalia margaritae* zone (early Pliocene); middle Pliocene part of Mao Formation, northern Dominican Republic.

Genus **PLECTODON** Carpenter, 1864

Plectodon Carpenter, 1864, pp. 611, 638.

Type species (*by original designation and monotypy*).—*Plectodon scaber* Carpenter, 1864, pp. 611, 638. Recent, Catalina Island, California, to Santa Inez Bay, east coast of Baja California, Mexico (Palmer, 1958, p. 80). Throughout the Gulf of California and south to Panama and the Galápagos Islands, Ecuador, in 20 to 250 m (Keen, 1971, p. 302).

Diagnosis.—Shell of medium to large size (up to 24 mm in length), rostrate, moderately delicate. Anteroventral margin evenly rounded. Exterior surface of shell covered by pustules. Resilium situated posterior to the umbo. Dorsal margin of left valve twisted just anterior to the umbo forming a small, toothlike projection. No lateral teeth in left valve. Right hinge with an anterior and a posterior lateral tooth.

Remarks.—The holotype of *P. scaber* (USNM 592441) unfortunately is broken into several fragments (see also Palmer, 1958, p. 80). Originally it was mounted on a piece of glass. The fragmentation probably happened when the specimen was removed from the glass. Other material of *P. scaber* is figured here (Pl. 2, figs. 5–8) for comparison with *P. granulatus.*

The stratigraphic range of the genus *Plectodon* is given as Pliocene to Recent (Dall, 1903, p. 1507). The single right valve from the Dominican Republic described below has been collected from sediments of late Miocene age, and the single valve from the middle Miocene Shoal River Formation of Florida reported by Gardner (1926, p. 64) as *Cuspidaria* (*Plectodon*) cf. *granulata* Dall extend the range of *Plectodon* from middle Miocene to Recent.

Plectodon granulatus (Dall, 1881)

Plate 2, figures 9, 10; Plate 5, figures 1–4; Plate 6, figures 1–4; Plate 7, figures 1–4; Text-figure 10

Neaera granulata Dall, 1881, p. 111.

Leiomya (*Plectodon*) *granulata* Dall. Dall, 1886, p. 300, pl. 3, fig. 8; Dall, 1889, p. 66, pl. 3, fig. 8.

Cuspidaria (*Plectodon*) *granulata* Dall. Dall, 1903, p. 1507.

? *Cuspidaria* (*Plectodon*) cf. *granulata* Dall. Gardner, 1926, p. 64.

Cuspidaria (*Plectodon*) *scabrata* Olsson and Harbison, 1953, p. 67, pl. 1, fig. 2.

Plectodon granulatus (Dall, 1881). Knudsen, 1982, p. 136.

Description.—Shell of medium size (up to 18 mm in length), rostrate, moderately delicate. Antero-ventral margin evenly rounded. Umbos prosogyrate. Exterior surface of shell covered by pustules. In the umbonal area there are fewer or no pustules; instead the growth lines are more clearly developed. Resilium located behind the umbo and somewhat toward the interior of the shell. Dorsal margin of the left valve twisted just in front of the umbo, forming a small, toothlike projection. No lateral teeth in left valve. Right hinge with an anterior and a posterior lateral tooth.

Lectotype (*selected herein*).—USNM 63193 (Pl. 2, figs. 9, 10).

Dimensions of lectotype.—Length 11.3 mm; height 6.7 mm.

Type locality.—Off Sombrero Island, Leeward Islands, Lesser Antilles, in 132 m (72 fathoms).

Remarks.—Lot USNM 63193 contains three specimens, the syntypes of *P. granulatus.* The specimen chosen as the lectotype is the left valve figured by Dall (1886, pl. 3, fig. 8). One of the paralectotypes is a right valve, the other paralectotype is also a left valve like the lectotype, but is considerably smaller. The two paralectotypes are USNM 887025 (*ex* USNM 63193).

The Dominican Neogene so far has yielded a single specimen of this species, a right valve. It is not quite complete: its postero-dorsal margin is somewhat damaged (Pl. 5, fig. 1). Unfortunately this unique specimen has been broken during handling for scanning electron microscopy (Pl. 5, fig. 3). Olsson and Harbison (1953, p. 67) state that their *P. scabratus* from the Pliocene of Fort Thompson, Florida, is less "narrow" than Recent specimens of *P. granulatus.* It is not clear, however, what is meant by "narrow". It probably refers to the ratio of height to length. In that respect there is some variability in *P. granulatus.* Two Recent specimens of *P. granulatus* are figured here for comparison (Pl. 6, figs. 1–4; Pl. 7, figs. 1–4).

Comparisons.—The only other species of *Plectodon* is the Recent Eastern Pacific *P. scaber* Carpenter (1864, pp. 611, 638) (for figures see Schenck, 1945, pl. 67, figs. 1–4; Palmer, 1958, pl. 6, figs. 6–8; Keen, 1971, p. 302, fig. 786; and Pl. 2, figs. 5–8). The main differences between the two species is size. *P. scaber* is considerably larger; it actually may be twice as large as *P. granulatus.*

Material.—Twelve lots with a total of 22 specimens as listed below:

1. 1 spec., NMB locality 16857: Río Cana, Dominican Republic; Cercado Formation (late Miocene).
2. 1 spec., USNM 63193: lectotype. Recent; Sombrero Island, Leeward Islands, Lesser Antilles, 72 fms.; Blake Coll.
3. 2 spec., USNM 887025: paralectotypes. Recent; Sombrero Island, Leeward Islands, Lesser Antilles, 72 fms.; Blake Coll.
4. 1 spec., USNM 63194: Recent; Barbados, 100 fms.

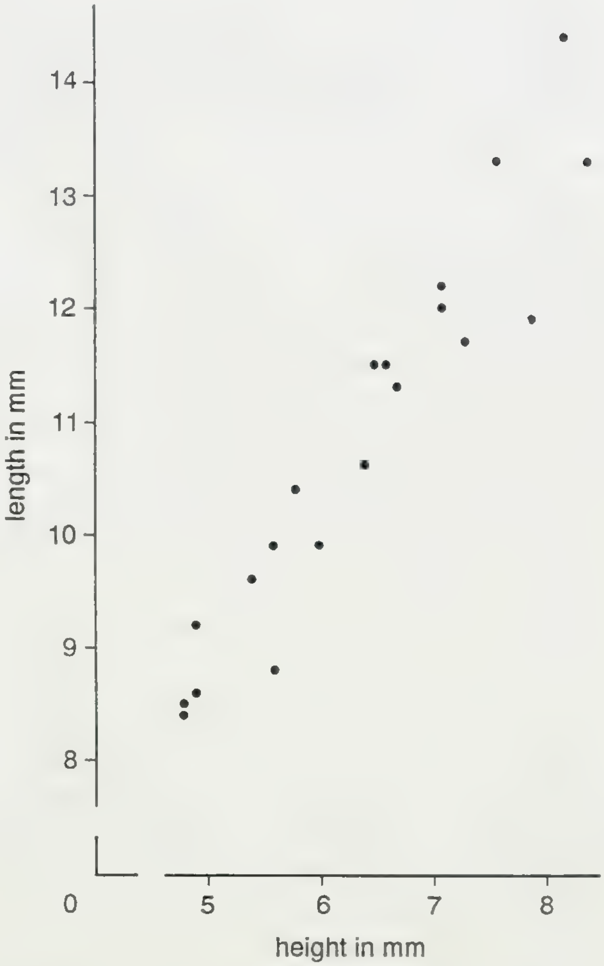
5. 6 spec., USNM 94214: Recent; Station 2648: off Cape Florida, 84 fms., sand.
6. 3 spec., USNM 667843: Recent; Station 1306: Campeche Bank off Yucatan, Mexico (22°10′N, 91°40′W), 42 fms., sand.
7. 1 spec., USNM 667668: Recent; Station 470: Campeche Bank off Yucatan, Mexico (22°30′N, 90°15′W), 46 fms., sand.
8. 1 spec., USNM 157815: Recent; Station 2404: between Mississippi Delta and Cedar Keys, Gulf of Mexico; 60 fms., sand.
9. 1 spec., USNM 64003: Recent; Station 2646: off Cape Florida; 85 fms.
10. 3 spec., USNM 97157: Recent; Station 2646: 5 miles off Cape Florida, Gulf of Mexico; 85 fms., sand.
11. 1 spec., USNM 157986: Recent; Station 2646: Recent; off Cape Florida, Gulf of Mexico; 85 fms., sand.
12. 1 spec., USNM 667737: Recent; Station 1241: Campeche Bank off Yucatan, Mexico (20°15′N, 92°10′W), 32 fms., sand.

Measurements.—Plotted in Text-figure 10.

Depth range.—From 37 to 274 m (Knudsen, 1982, p. 137).

Occurrence.—Cercado Formation (late Miocene) of Río Cana section: NMB locality 16857 (Saunders *et al.*, 1986, text-figs. 15, 16).

Distribution.—Shoal River Formation (middle Miocene), Florida? Cercado Formation (late Miocene), northern Dominican Republic. Pliocene, Florida. Recent, southern Florida and Gulf of Mexico throughout the West Indies.



Text-figure 10.—Length/height diagram of *Plectodon granulatus* (Dall, 1881).

Family **VERTICORDIIDAE** Stoliczka, 1871

Genus **HALIRIS** Dall, 1886

Haliris Dall, 1886, p. 287.

Type species (by original designation).—*Verticordia fischeriana* Dall, 1881. Recent, Gulf of Mexico. North Carolina to Gulf of Mexico to Barbados (Abbott, 1974, p. 563).

Diagnosis.—Shell small (up to 7 mm in length), globose. Umbos strongly prosogyrate. Lunule somewhat depressed. Ventral margin evenly rounded or somewhat angulated near its middle. Entire surface sculptured by numerous radial ribs. No secondary radial ribs. Surface granulated. Interior surface nacreous, its ventral margin fluted. Hinge of left valve consisting of a hardly recognizable, subumbonal cardinal tooth and (only in fully adult shells) an inconspicuous posterior lateral tooth. Hinge of right valve with a prominent, subumbonal cardinal tooth and a posterior lateral tooth.

Remarks.—Numerous Recent specimens of the type species, *H. fischeriana,* are available. Some of them are figured (Pl. 8, figs. 1–6) for comparison with *H. jamaicensis.* The stratigraphic range of the genus is Eocene to Recent.

Haliris jamaicensis (Dall, 1903)

Plate 9, figures 1–6; Plate 10, figures 1–4

Verticordia (Haliris) jamaicensis Dall, 1903, p. 1511; Woodring, 1925, p. 93, pl. 11, figs. 9–11.

Description.—Shell small (up to less than 5 mm in length), globose. Umbos strongly prosogyrate. Lunule depressed. Ventral margin slightly angulated near its middle. Surface sculptured by 23 to 26 radial ribs; interspaces narrower on anterior part of shell. Whole surface granulated. Inner surface nacreous, its ventral margin fluted. Hinge of left valve consisting of a hardly recognizable, subumbonal cardinal tooth and (only in fully adult shells) an inconspicuous, posterior lateral tooth. Hinge of right valve with a prominent, subumbonal cardinal tooth and a posterior lateral tooth.

Lectotype (selected herein).—USNM 135686. This is the specimen figured by Woodring (1925, pl. 11, fig. 10), a right valve.

Dimensions of lectotype.—Length 4.5 mm; height 4.7 mm.

Type locality.—Bowden, Jamaica. Bowden Formation (early Pliocene).

Paralectotype.—USNM 482413. This is the specimen figured by Woodring (1925, pl. 11, fig. 9), a right valve.

Dimensions of paralectotype USNM 482413.—Length 3.8 mm; height 3.8 mm.

Paralectotype.—USNM 482414. This is the specimen figured by Woodring (1925, pl. 11, fig. 11), a left valve.

Dimensions of paralectotype USNM 482414.—Length 3.3 mm; height 3.1 mm.

Remarks.—The lectotype of *H. jamaicensis* is the largest of the 10 available specimens. Its height is greater than its length. In all the other specimens the length is greater (or the same as) than the height.

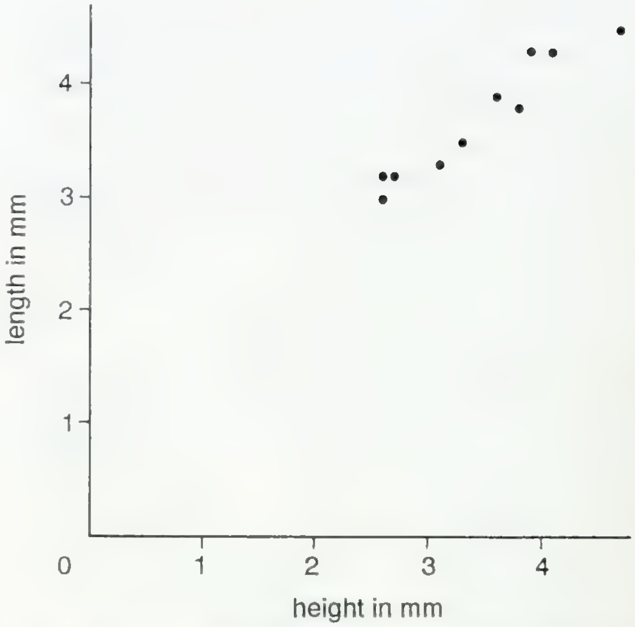
The type material of this species consists of the lectotype and the two paralectotypes mentioned above. All three specimens are glued to a piece of black paper. As explained under *Cardiomya* (*Bowdenia*) *distira* it has not been possible to remove the specimens from the black paper. Therefore the lectotype is not refigured here.

Woodring (1925, p. 93) mentioned a fragment from the early Pliocene Bowden Formation of Jamaica that is almost three times as large as the specimens listed below under "Material". More specimens from Bowden would be needed in order to be able to identify the fragment mentioned above.

Comparisons.—*H. jamaicensis* is obviously closely related to the living *H. fischeriana* (Dall) (1881, p. 106), the type species of the genus. *H. fischeriana* is larger than *H. jamaicensis* and has more radial ribs. In addition the ventral margin is evenly rounded in *H. fischeriana* but somewhat angulated in *H. jamaicensis.*

Material.—Four lots with a total of only ten specimens as listed below:

1. 2 spec., NMB locality 15832: Río Gurabo, Dominican Republic; middle Pliocene part of Mao Formation.
2. 1 spec., TU locality 1227A (= NMB locality 18582): Arroyo Zalaya, Dominican Republic; *Globorotalia margaritae* zone (early Pliocene).
3. 4 spec., NMB locality 10635: Bowden, Jamaica; Bowden Formation (early Pliocene).
4. 3 spec., USNM 135686 (lectotype) and two paralectotypes (USNM 482413, 482414). Bowden, Jamaica; Bowden Formation (early Pliocene).



Text-figure 11.—Length/height diagram of *Haliris jamaicensis* (Dall, 1903).

Measurements.—Plotted in Text-figure 11.

Occurrence.—*Globorotalia margaritae* zone (early Pliocene) of Arroyo Zalaya: TU locality 1227A and middle Pliocene part of Mao Formation of Río Gurabo section: NMB locality 15832 (Saunders *et al.*, 1986, text-figs. 4, 6).

Distribution.—Bowden Formation (early Pliocene) of Bowden, Jamaica. Early Pliocene *Globorotalia margaritae* zone and middle Pliocene part of Mao Formation, Dominican Republic.

Genus **TRIGONULINA** d'Orbigny, 1842

Trigonulina d'Orbigny, 1842 (see also d'Orbigny, 1845?, p. 327).

Type species (by monotypy).—*Trigonulina ornata* d'Orbigny, 1842 (see also d'Orbigny, 1845?, p. 327). Recent, Massachusetts to Florida and the West Indies, Bermuda, Brasil (Abbott, 1974, p. 563).

Diagnosis.—Shell small (up to almost 6 mm in length), oval. Umbos low, strongly prosogyrate. Lunule deeply depressed. Sculpture consisting of few, widely spaced, high, and narrow radial ribs projecting beyond ventral margin. On the posterior slope there is a large area without radial ribs. Interior surface nacreous, its ventral margin fluted. Ligament internal. No teeth in left valve. Right valve with a strong, projecting, subumbonal, cardinal tooth and a groove along postero-dorsal margin to receive postero-dorsal margin of left valve.

Remarks.—The Spanish edition of Ramón de la Sagra's *Historia física, política y natural de la Isla de Cuba,* volume 5 (molluscs) of the second part (natural history), is dated 1845. On page 327, where *Trigonulina* and its type species, *T. ornata,* are described, the date is given as 1846. According to Aguayo (1943, p. 38) publication of this edition appears to have started in 1844 already and was probably completed only in 1853. Aguayo is quoting the Spanish edition as of 1845?, to which the present author is adding [1844-1853?] in the "References Cited". Dall (1889, p. 18) did not have access to the Spanish edition.

Both Dall (1889, p. 18) and Aguayo (1943, p. 38) commented on the dates of publication of the French edition. Both authors state that the atlas was published in 1842. The figures of *T. ornata* given in this atlas (pl. 27, figs. 30–33) are an indication as defined in Article 12b(7) of the International Code of Zoological Nomenclature (third edition, 1985).

Trigonulina is here used as a full genus, whereas Abbott (1974, p. 563) and Woodring (1925, p. 92) treated it as a subgenus of *Verticordia* J. Sowerby (1812–1846, p. 68, pl. 639, 1844 [for date of publication of plate 639 see Renevier, 1855, and Sykes, 1906]. On the other hand Keen (1971, p. 302) considered *Trigonulina* as a synonym of the subgenus *Verticordia s.s.* The type species of *Verticordia* is *V. cardiiformis* J. Sowerby (1812–1846, p. 68, pl. 639, 1844) from the Pliocene of England. The original figure shows that the 13 radial ribs are evenly distributed over the entire shell disc. In *Trigonulina,* however, there is a space without radial ribs on the postero-dorsal slope.

T. ornata d'Orbigny, the type species of *Trigonulina,* is not only reported from Western Atlantic waters, but is also said to occur in the Eastern Pacific (Keen, 1971, p. 302). Having looked at a number of lots from both oceans I come to the conclusion that they are distinct and that the species from the Eastern Pacific therefore needs a name. For this reason these two living species are briefly discussed and compared below.

The stratigraphic range of *Trigonulina* is Eocene to Recent.

Trigonulina ornata d'Orbigny, 1842

Plate 11, figures 1–4; Plate 12, figures 1–4; Text-figures 12, 13

Trigonulina ornata d'Orbigny, 1842, pl. 27, figs. 30–33; 1845?, p. 327.

Verticordia caelata Verrill, 1882, p. 566; 1884, p. 278, pl. 30, figs. 9, 9a.

Verticordia (Trigonulina) ornata D'Orbigny. Dall, 1886, p. 290 (part). Dall and Simpson, 1901, p. 498 (part). (For further citations see Dall, 1886.)

Verticordia (Trigonulina) ornata (Orbigny, 1842). Abbott, 1974, p. 563, fig. 6158.

Verticordia ornata (Orbigny, 1846). Knudsen, 1982, p. 128 (part). For additional citations see this publication.

Verticordia ornata (Orbigny, 1842). Rios, 1985, p. 282, pl. 99, fig. 1390 (part).

Description.—Shell small (up to 5 mm in length), oval. Umbos low, strongly prosogyrate. Lunule deeply impressed in both valves, but more so in left valve. Sculpture consisting of eight to twelve high, narrow, radial ribs anterior to the unsculptured posterior slope projecting beyond the ventral margin. Surface of perfectly preserved valves covered by minute pustules forming rows parallel to the ribs. Interior surface nacreous, its ventral margin fluted. No teeth in left valve. Right valve with a strong, subumbonal, cardinal tooth and a groove along postero-dorsal margin to receive postero-dorsal margin of left valve.

Holotype.—BMNH Cat. no. 493; Reg. no. 1854.10.4.557, a left valve.

Dimensions of holotype.—Length 2.6 mm; height 2.3 mm.

Type locality.—"Jamaica" (from sand). This is the only information given with the original description.

Remarks.—The holotype of *T. ornata* is at hand. Its ventral margin is somewhat damaged. It is a left valve. It is the specimen figured in an idealized way and in mirror-image by d'Orbigny (1842, pl. 27, figs. 30, 31). His Figure 31 shows the interior of the valve with a hinge without teeth, a hinge typical for left valves. The holotype is one of the rare cases of a specimen having only eight radial ribs in front of the posterior slope. Due to its imperfect preservation it is not refigured here.

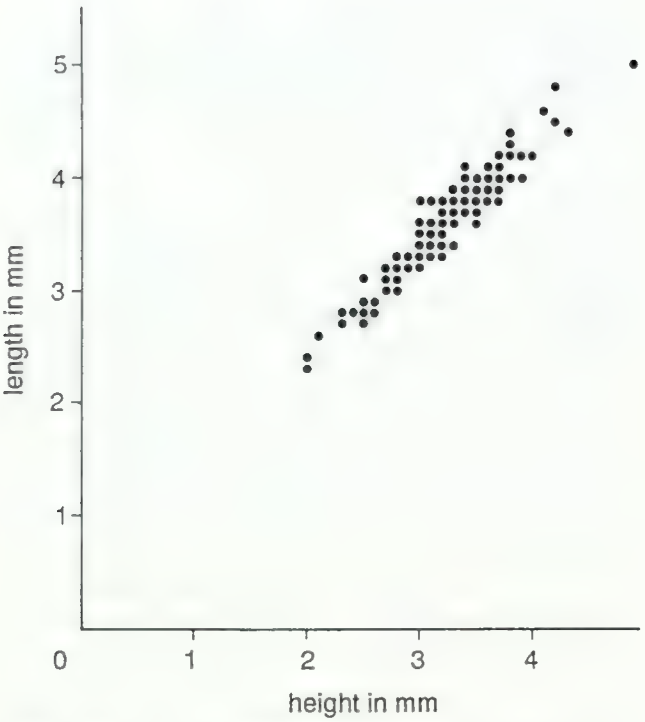
As listed under "Material", six lots with 1049 specimens have been used for the description given above. Out of these 1049 specimens 190 valves have been measured (Text-fig. 12) and their ribs in front of the unsculptured posterior slope counted (Text-fig. 13). As indicated in the description the range of the number of ribs is eight to twelve. However, the extremes are rare (Text-fig. 13); there are only three valves with eight ribs, eight valves with nine ribs, and twelve valves with twelve ribs. In other words one should really describe *T. ornata* as having ten or eleven ribs.

The original description of *Verticordia caelata* Verrill was based on a single right valve with eleven ribs.

Comparisons.—Comparative remarks are given below under *T. pacifica* and *T. bowdenensis.*

Material.—Six lots with a total of 1049 specimens as listed below (quoted from specimen labels):

1. 439 spec., USNM 444664: Eolis Station 368: off Ajax Reef, Florida; 80–100 fms.



Text-figure 12.—Length/height diagram of *Trigonulina ornata* d'Orbigny, 1842.

2. 54 spec., USNM 444479: Eolis Station 178: off Fowey Light, Florida; 68 fms.
3. 3 spec., USNM 63214: off Hatteras; 15–124 fms.
4. 172 spec., USNM 444514: Eolis Station 311: off Govt. cut, Miami, Florida; 75 fms.
5. 337 spec., USNM 444665: Eolis Station 370: off Ajax Reef, Florida; 70–90 fms.
6. 44 spec., USNM 444653: Eolis Station 363: off Fowey Light, Florida; 85 fms.

Measurements.—Plotted in Text-figure 12.

Depth range.—From 5 to 850 m (Knudsen, 1982, p. 128) and 15 to 1256 m (Hertlein and Grant, 1972, p. 344).

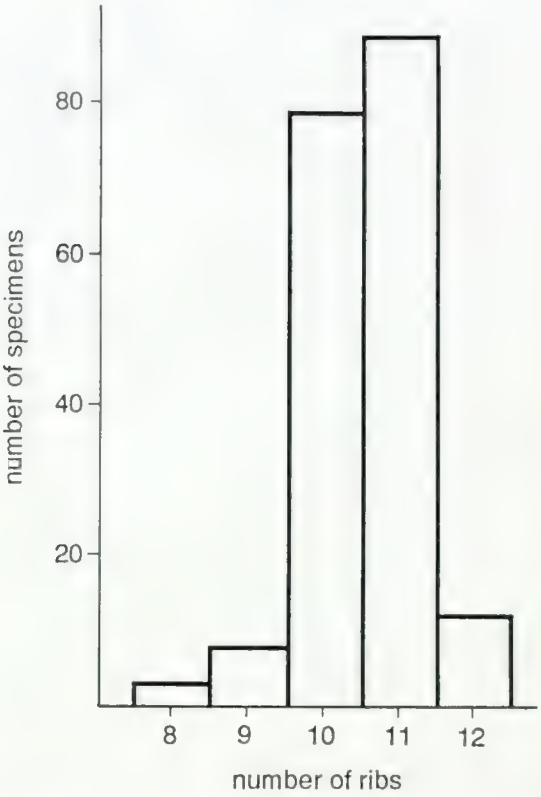
Distribution.—Massachusetts to Florida and the West Indies, Bermuda, Brazil (Abbott, 1974, p. 563) or from about 42°N to about 30°42′S (Knudsen, 1982, p. 128). So far *T. ornata* has not been reported as a fossil.

Trigonulina pacifica, new species
Plate 2, figures 11, 12; Plate 13, figures 1–4;
Plate 14, figures 1–4; Text-figures 14, 15

Verticordia ornata (d'Orbigny). Grant and Gale, 1931, p. 266, pl. 13, fig. 4 (part).

Verticordia (*Verticordia*) *ornata* (Orbigny, 1846). Keen, 1971, p. 302, fig. 789 (part).

Verticordia (*Trigonulina*) *ornata* d'Orbigny. Hertlein and Grant, 1972, p. 344, pl. 43, figs. 23, 26, 27, 31.



Text-figure 13.—Histogram showing rib number distribution of *Trigonulina ornata* d'Orbigny, 1842.

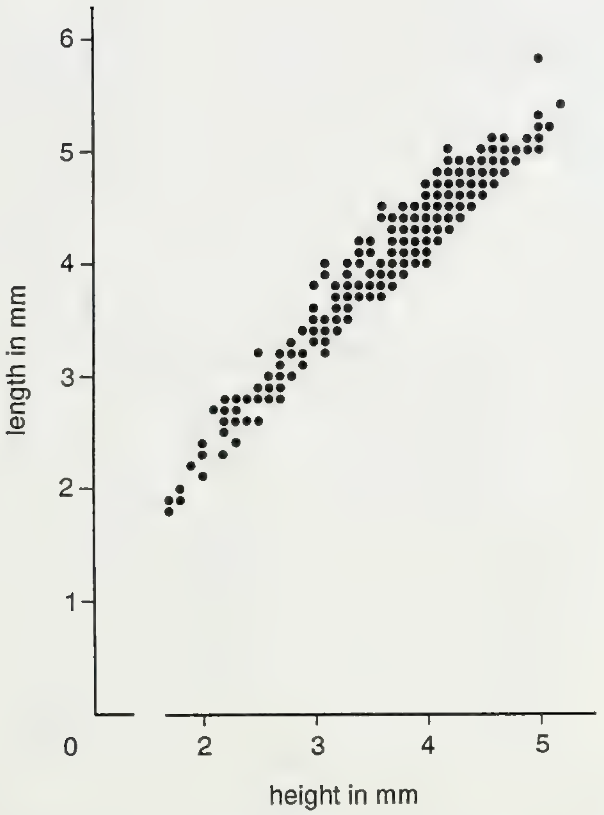
Description.—Shell small (up to almost 6 mm in length), oval. Umbos low, strongly prosogyrate. Lunule deeply impressed in both valves, but more so in left valve. Sculpture consisting of six to 12 high, narrow radial ribs anterior to the unsculptured posterior slope projecting beyond the ventral margin. Surface of perfectly preserved valves covered by minute, not closely spaced pustules forming rows parallel to the ribs. Interior surface nacreous, its ventral margin fluted. No teeth in left valve. Right valve with a strong, subumbonal, cardinal tooth and a groove along postero-dorsal margin to receive the postero-dorsal margin of left valve.

Holotype.—LACM 2718 (Pl. 2, figs. 11, 12).

Dimensions of holotype.—Length 4.8 mm; height 4.2 mm.

Type locality.—(quoted from specimen label) LACM 65-6.22: 0.4–0.7 miles 110 to 132 degrees T from Ship Rock, Santa Catalina Island, California Channel Islands, California (33°27′N, 118°30′W). Depth: 82 m.

Remarks.—The basis for the above description consists of the 23 lots with 1840 specimens listed under "Material". A total of 320 specimens have been measured (Text-fig. 14) and their ribs in front of the ribless



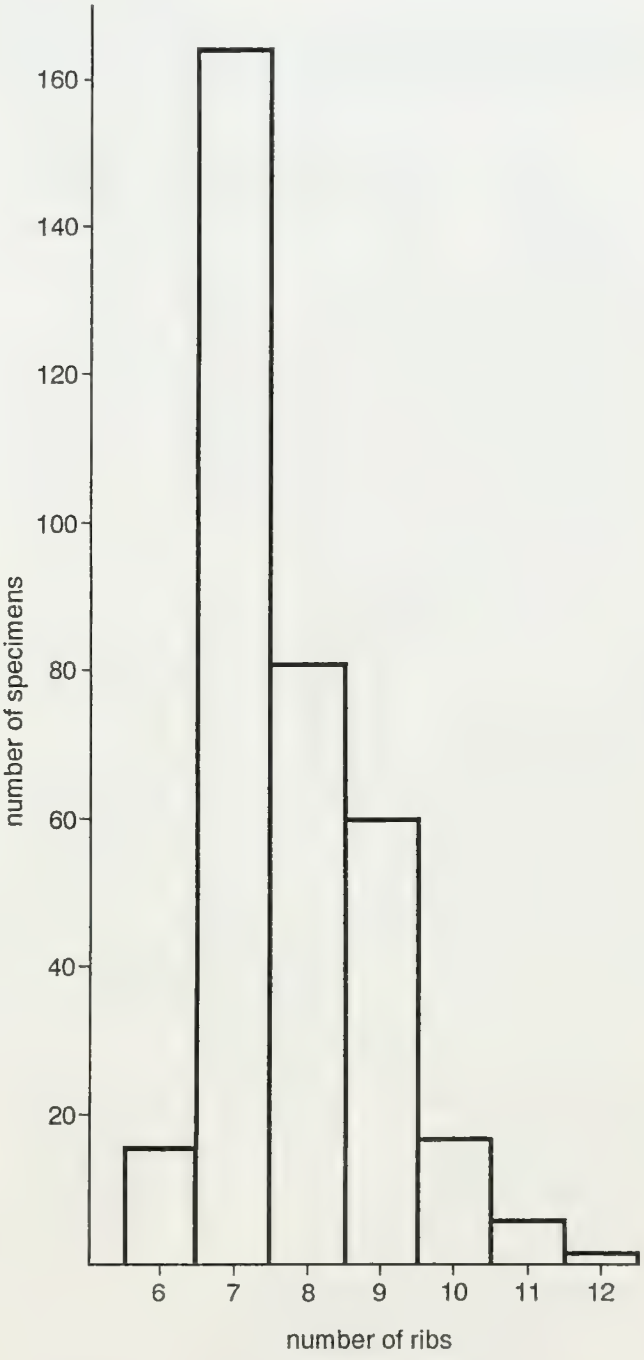
Text-figure 14.—Length/height diagram of *Trigonulina pacifica*, new species.

posterior slope counted (Text-fig. 15). The range of the number of ribs as given in the description is six to 12. But again—as in *T. ornata*—the extremes are rare: there are only 16 valves with six ribs, 17 valves with 10 ribs, six valves with 11 ribs, and a single valve with 12 ribs. It is therefore appropriate to say that the great majority of the valves has seven to nine ribs.

The ribs of *T. pacifica* as a rule are high and narrow. But sometimes there are exceptions with lower and somewhat broader ribs.

Comparisons.—*T. pacifica* reaches larger dimensions than the Recent West Indian *T. ornata* d'Orbigny and has fewer radial ribs. In addition the general outline of the shell is more rounded or oval in *T. ornata*, and the area without ribs on the posterior slope of *T. ornata* is wider than that of *T. pacifica*. *T. pacifica* is considerably larger than *T. bowdenensis* Dall from the early Pliocene Bowden Formation of Jamaica but has about the same number of radial ribs.

The microsculpture of *T. ornata* and *T. pacifica* are clearly different. In both species the microsculpture consists of rounded pustules, which are aligned in rows parallel to the ribs; but in *T. ornata* they are much more closely spaced (Pl. 12, Figs. 2, 4; Pl. 14, Figs. 2, 4). In *T. bowdenensis* on the other hand the pustules are more closely spaced than in *T. pacifica* but not as closely as in *T. ornata* (Pl. 18, Figs. 2, 4). However, the pustules of *T. bowdenensis* have a different shape; they are not rounded but pointed (Pl. 16, Figs. 3, 5).



Text-figure 15.—Histogram showing rib number distribution of *Trigonulina pacifica*, new species.

The diagnostic features of the three species of *Trigonulina* discussed above are tabulated in Table 3.

Although there are clear differences in the micro-

Table 3.—Diagnostic features of the three species of *Trigonulina* dealt with herein. Numbers of measured specimens: *T. ornata*: 190; *T. pacifica*: 320; *T. bowdenensis*: 79

	maximum length	*maximum height*	*mean ratio length/ height*	*ribless area on posterior slope*	*range of number of ribs*	*most frequent number of ribs*	*microsculpture*		*depth range (in m)*
							spacing of pustules	*form of pustules*	
T. ornata	5.0	4.9	1.13	wide	8–12	11	close	rounded	5–1256
T. pacifica	5.8	5.2	1.09	narrower	6–12	7	wide	rounded	18–168
T. bowdenensis	4.0	3.5	1.16	wide	7–10	10	not wide	pointed	—

sculpture of these species, considerably more numerous, well preserved specimens should be looked at in the scanning electron microscope in order to determine the range of variability of the microsculpture.

Material.—23 lots with a total of 1840 specimens as listed below (lots arranged from north to south) (quoted from specimen labels):

1. 3 spec., paratypes. LACM 63-50.12: 60 m, Humpback Rock, off Hopkins Marine Station, Pacific Grove, Monterey Bay, California (36°38′N, 121°54′W). Leg. J.H. McLean, R/V Tage, 26 November 1963.
2. 3 spec., paratypes. LACM 41-80.19: 99–102 m, mud, sand and shell, 1.5 mi NW of Cavern Pt., Santa Cruz Id., California Channel Ids., California (34°04′N, 119°34.4′W). Leg. R/V Velero III (AHF 1300-41), 12 April 1941. Ex AHF.
3. 2 spec., paratypes. LACM 40-164.20: 27–91 m, sand and gravel, Anacapa Passage, W of Anacapa Id., California Channel Ids., California (33°59.0′N, 119°32.1′W). Leg. R/V Velero III (AHF 1190-40), 30 October 1940. Ex AHF.
4. 1 spec., paratype. LACM 41-74.19: 62–75 m, sand and shell, 0.5 mi S of Gull Id., Santa Cruz Id., California Channel Ids., California (33°56.5′N, 119°49.6′W). Leg. R/V Velero III (AHF 1294-41), 11 April 1941. Ex AHF.
5. 8 spec., holotype and 7 paratypes. LACM 65-6.22: 82 m, 0.4–0.7 mi 110 to 132 degrees T from Ship Rock, Santa Catalina Id., California Channel Ids., California (33°27′N, 118°30′W). Leg. R. Reimer et al., R/V Velero IV, 13 February 1965. Ex AHF.
6. 4 spec., paratypes. LACM 41-25.17: 75 m, shell, mud and gray sand, 4 mi N of Islas Todos Santos, Pacific Coast, Baja California, Mexico (31°53.3′N, 116°48.3′W). Leg. R/V Velero III (AHF 1245-41), 24 February 1941. Ex AHF.
7. 12 spec., paratypes. LACM 75-93.17: 27 m, gravel and shell, W of Isla Smith, Bahía de los Angeles, Gulf of California, Mexico (29°04′N, 113°33′W). Leg. Gale Sphon, D.K. Mulliner, 10 October 1975.
8. 21 spec., paratypes. LACM 76-2.21: 18–22 m, sand and gravel, W of Isla Smith, Bahía de los Angeles, Gulf of California, Mexico (29°03.7′N, 113°31.0′W). Leg. Gale Sphon, D.K. Mulliner, 10–16 May 1976.
9. 25 spec., paratypes. LACM 71-158.38: 31–37 m, shelly sand, Kellett Channel, S of Isla Cedros, Pacific Coast, Baja California, Mexico (27°57.0′N, 115°08.5′W). Leg. J.H. McLean, P.I. LaFollette, R/V Searcher, 20 October 1971.
10. 24 spec., paratypes. LACM 78-120.18: 43–55 m, sandy, off Isla Danzante, Bahía Escondido, Gulf of California, Baja California Sur, Mexico (25°46′N, 111°15′W). Leg. D. Mulliner, G. Sphon, 6 November 1978.
11. 384 spec., paratypes. USNM 211469: off La Paz, Baja California, Mexico; 9½–10 fms.
12. 623 spec., paratypes. USNM 211458: off La Paz, Baja California, Mexico; 26½ fms.
13. 591 spec., paratypes. USNM 151959: near La Paz, off Baja California, Mexico; 9½–10 fms.
14. 13 spec., paratypes. LACM 66-23.22: 27–37 m, sand, off Punta Arena de la Ventana, Gulf of California, Baja California Sur, Mexico (24°04′N, 109°49′W). Leg. J.H. McLean, P. M. Oringer, L. Marincovich, 8 April 1966.
15. 6 spec., paratypes. LACM 66-22.40: 18–55 m, sand and shell, directly off anchorage at Bahía de los Muertos, Gulf of California, Baja California Sur, Mexico (23°58′N, 109°46′W). Leg. J.H. McLean et al., 8 April 1966.
16. 6 spec., paratypes. LACM 66-17.62: 18–37 m, sand, between Rancho El Tule and Rancho Palmilla, Gulf of California, Baja California Sur, Mexico (22°58′N, 109°45′W). Leg. J.H. McLean, P.M. Oringer, 5 April 1966.
17. 10 spec., paratypes. LACM 38-5.9: 37–73 m, Bahía Banderas, Jalisco, Mexico (20°40′N, 105°25′W). Leg. G. Willett, 14 February 1938.
18. 31 spec., paratypes. LACM 34-2.20: 26–33 m, sand, nullipores, Bahía Braithwaite, Isla Socorro, Islas Revilla Gigedo, Mexico (18°42.5′N, 110°56.22′W). Leg. R/V Velero III (AHF 129-34), 3 January 1934. Ex AHF.

19. 8 spec., paratypes. LACM 38-9.11: 73–128 m, Bahía Guatulco, Oaxaca, Mexico. Leg. G. Willett, 7 March 1938.
20. 11 spec., paratypes. LACM 72-13.26: 37 m, mud, 0.5 to 1.5 mi W Roca Vagares, Bahía Juanillo, Guanacaste Prov., Costa Rica (10°57.47′N, 85°45.3′W). Leg. D. Cadien, P.I. LaFollette, R/V Searcher (Searcher 393), 14 February 1972.
21. 27 spec., paratypes. LACM 72-54.45: 37 m, off Bahía Herradura, Puntarenas Prov., Costa Rica (9°38.8′N, 84°40.8′W). Leg. J.H. McLean, W. Bussing, R/V Searcher (Searcher 451, 457), 10 March 1972.
22. 15 spec., paratypes. LACM 72-53.27: 21 m, sand, anchorage in Bahía Herradura, Puntarenas Prov., Costa Rica (9°37.97′N, 84°40.5′W). Leg. J.H. McLean, R/V Searcher, 9 March 1972.
23. 12 spec., paratypes. LACM 72-57.33: 21 m, sand, anchorage inside small islet 1.5 km S Punta Quepos, Puntarenas Prov., Costa Rica (9°22.72′N, 84°09.68′W). Leg. J.H. McLean, R/V Searcher, 11 March 1972.

Measurements.—Plotted in Text-figure 14.

Depth range.—From 18 to 168 m (Keen, 1971, p. 302).

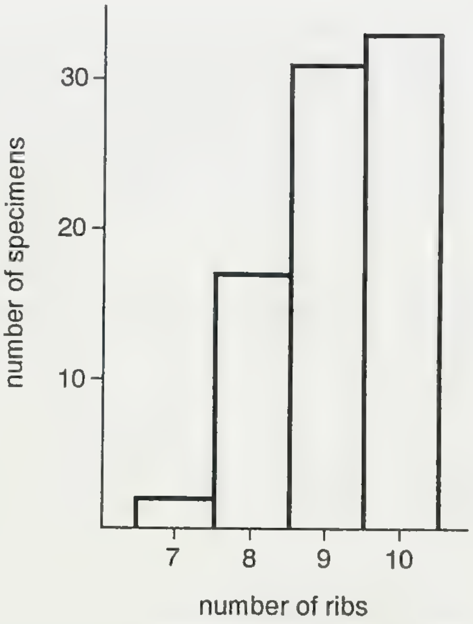
Distribution.—Pliocene of San Diego, California (Hertlein and Grant, 1972, p. 344); Pleistocene of California (Grant and Gale, 1931, p. 266). Recent from Catalina Island, California, through the Gulf of California, south to Peru and the Galápagos Islands (Keen, 1971, p. 302) or from about 34°N to 12°S (Knudsen, 1982, p. 128). The record from Monterey Bay (lot 1) extends the distribution to the north to almost 37°N.

Trigonulina bowdenensis (Dall, 1903)

Plate 15, figures 1–4; Plate 16, figures 1–5; Plate 17, figures 1–4; Plate 18, figures 1–4;
Text-figures 16, 17

Verticordia (*Trigonulina*) *bowdenensis* Dall, 1903, p. 1512; Woodring, 1925, p. 92, pl. 11, figs. 6–8.

Description.—Shell small (up to 4 mm in length), oval to rotund. Umbos low, strongly prosogyrate. Lunule more deeply impressed in left valve. Sculpture consisting of seven to 10 high, narrow, radial ribs anterior to unsculptured posterior slope, which project beyond ventral margin. Surface of perfectly preserved valves covered by minute, pointed pustules forming rows parallel to ribs. Along postero-dorsal margin there are two closely spaced, narrow ribs. Interior surface nacreous, its ventral margin fluted. No teeth in left valve. Right valve with a strong, subumbonal, cardinal tooth and a groove along postero-dorsal margin to receive postero-dorsal margin of left valve.



Text-figure 16.—Histogram showing rib number distribution of *Trigonulina bowdenensis* (Dall, 1903).

Lectotype (*selected herein*).—USNM 135689. This is the specimen figured by Woodring (1925, pl. 11, fig. 6), a left valve.

Dimensions of lectotype.—Length 3.1 mm; height 2.8 mm.

Type locality.—Bowden, Jamaica. Bowden Formation (early Pliocene).

Paralectotype.—USNM 482415. This is the specimen figured by Woodring (1925, pl. 11, fig. 7), a left valve.

Dimensions of paralectotype USNM 482415.—Length 2.7 mm; height 2.4 mm.

Paralectotype.—USNM 482416. This is the specimen figured by Woodring (1925, pl. 11, fig. 8), a right valve.

Dimensions of paralectotype USNM 482416.—Length 3.0 mm; height 2.5 mm.

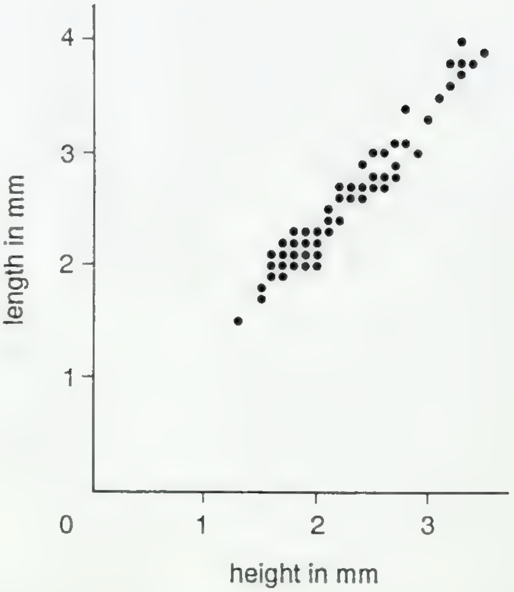
Remarks.—The type material of this species consists of the lectotype and the two paralectotypes mentioned above. All three specimens are glued to a piece of black paper. As explained under *Cardiomya* (*Bowdenia*) *distira,* it has not been possible to remove the specimens from the black paper. The lectotype is therefore not refigured here.

As hinted at in the above description, there is some variability as to the number of radial ribs. The large majority of the specimens at hand has eight to 10 radial ribs. Only two valves out of the 90 available specimens have only seven radial ribs (Text-fig. 16). One is from Jamaica, the other from the Dominican Republic.

Comparisons.—The Recent Caribbean *T. ornata* d'Orbigny is larger than *T. bowdenensis* and has more radial ribs. The Recent Eastern Pacific *T. pacifica* has about the same number of radial ribs as *T. bowdenensis* but reaches even larger dimensions than *T. ornata* (see also "Comparisons" under *T. pacifica*).

Material.—32 lots with a total of 112 specimens as listed below:

1. 1 spec., NMB locality 16802: Río Mao; Cercado Formation (late Miocene).
2. 2 spec., TU locality 1293 (= NMB locality 18583): Río Mao, Bluff 1 of Maury; late Miocene.
3. 1 spec., NMB locality 15804: Río Gurabo; Gurabo Formation (early Pliocene).
4. 1 spec., NMB locality 15823: Río Gurabo; Mao Formation (early Pliocene).
5. 2 spec., NMB locality 15828: Río Gurabo; Mao Formation (early to middle Pliocene).
6. 5 spec., NMB locality 15829: Río Gurabo; Mao Formation (middle Pliocene).
7. 12 spec., NMB locality 15846: Río Gurabo; Gurabo Formation (late Miocene).
8. 1 spec., NMB locality 15849: Río Gurabo; Gurabo Formation (late Miocene).
9. 6 spec., NMB locality 15863: Río Gurabo; Gurabo Formation (late Miocene).
10. 1 spec., NMB locality 15864: Río Gurabo; Gurabo Formation (late Miocene).
11. 2 spec., NMB locality 15865: Río Gurabo; Gurabo Formation (late Miocene).
12. 1 spec., NMB locality 15869: Río Gurabo; Gurabo Formation (late Miocene).
13. 1 spec., NMB locality 15937: Río Gurabo; Gurabo Formation (early Pliocene).
14. 1 spec., NMB locality 15945: Río Gurabo; Gurabo Formation (late Miocene).
15. 1 spec., NMB locality 15962: Río Gurabo; Gurabo Formation (early Pliocene).
16. 1 spec., NMB locality 16031: Río Gurabo; Mao Formation (early Pliocene).
17. 2 spec., NMB locality 16034: Río Gurabo; Mao Formation (early Pliocene).
18. 1 spec., TU locality 1210 (= NMB locality 18579): Río Gurabo; Gurabo Formation (early Pliocene).
19. 2 spec., TU locality 1211 (= NMB locality 18580): Río Gurabo; latest Miocene part of Gurabo Formation.
20. 2 spec., TU locality 1215 (= NMB locality 18581): Río Gurabo; Gurabo Formation (late Miocene).
21. 6 spec., NMB locality 16817: Río Cana; Gurabo Formation (early Pliocene).



Text-figure 17.—Length/height diagram of *Trigonulina bowdenensis* (Dall, 1903).

22. 3 spec., NMB locality 16818: Río Cana; Gurabo Formation (early Pliocene).
23. 4 spec., NMB locality 16824: Río Cana; Gurabo Formation (early Pliocene).
24. 1 spec., NMB locality 16828: Río Cana; Gurabo Formation (late Miocene).
25. 1 spec., NMB locality 16832: Río Cana; Gurabo Formation (late Miocene).
26. 2 spec., NMB locality 16833: Río Cana; Gurabo Formation (late Miocene).
27. 1 spec., NMB locality 16961: Río Cana; Gurabo Formation (early Pliocene).
28. 1 spec., NMB locality 17026: Río Cana; Cercado Formation (late Miocene).
29. 10 spec., TU locality 1354 (= NMB locality 18585): Río Cana, Cañada de Zamba; Gurabo Formation (early Pliocene).
30. 5 spec., TU locality 1250 (= NMB locality 18558): Río Verde; Gurabo Formation (late Miocene or early Pliocene).
31. 29 spec., NMB locality 10635: Bowden, Jamaica; Bowden Formation (early Pliocene).
32. 3 spec., USNM 135689 (lectotype) and two paralectotypes (USNM 482415, 482416). Bowden, Jamaica; Bowden Formation (early Pliocene).

Measurements.—Plotted in Text-figure 17.

Occurrence.—This species is recorded from the following areas:

Río Mao: Cercado Formation (late Miocene): NMB locality 16802, TU locality 1293 (Saunders *et al.*, 1986, text-fig. 29).

Río Gurabo: late Miocene part of Gurabo Formation: NMB localities 15846, 15849, 15863, 15864, 15865, 15869, 15945 and TU localities 1211, 1215. Early Pliocene part of Gurabo Formation: NMB localities 15804, 15937, 15962, and TU locality 1210. Mao Formation (early Pliocene and early to middle Pliocene): NMB localities 15823, 15828, 15829, 16031, 16034. For location see Saunders *et al.*, 1986, text-figs. 4–6).

Río Cana: Cercado Formation (late Miocene): NMB locality 17026. Late Miocene part of Gurabo Formation: NMB localities 16828, 16832, 16833. Early Pliocene part of Gurabo Formation: NMB localities 16817, 16818, 16824, 16961, and TU locality 1354 (Saunders *et al.*, 1986, text-figs. 15, 16).

Río Verde: Gurabo Formation: TU locality 1250 (Saunders *et al.*, 1986, text-fig. 38).

Distribution.—Bowden Formation (early Pliocene) of Bowden, Jamaica. Cercado Formation (late Miocene), late Miocene and early Pliocene parts of Gurabo Formation, and Mao Formation (early Pliocene and early to middle Pliocene), Dominican Republic.

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PLATES

EXPLANATION OF PLATE 1

Figure Page

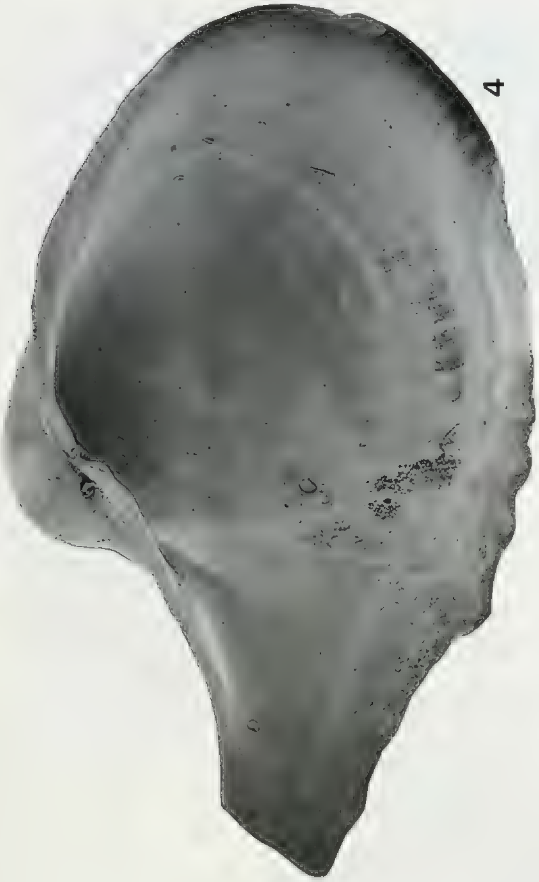
1–6. *Cardiomya* (*Cardiomya*) *islahispaniolae* (Maury, 1917). 42

1. NMB G 14145. NMB locality 15907: Río Gurabo, Dominican Republic; uppermost part of Cercado Formation (late Miocene). Exterior of right valve. Length 9.3 mm; height 5.4 mm.

2, 3. NMB G 14144. NMB locality 16923: Río Mao, Arroyo Bajón, Dominican Republic; Cercado Formation (late Miocene). Right valve. 2. Enlargement of hinge, ×30. 3. Interior. Length 8.4 mm; height 5.2 mm.

4, 5. NMB G 14146. NMB locality 15903: Río Gurabo, Dominican Republic; upper part of Cercado Formation (late Miocene). Left valve. 4. Interior. 5. Enlargement of hinge, ×30. Length 8.7 mm; height 5.8 mm.

6. NMB G 14147. NMB locality 16929: Río Mao, Dominican Republic; Cercado Formation (late Miocene). Exterior of left valve. Length 7.6 mm; height 4.8 mm.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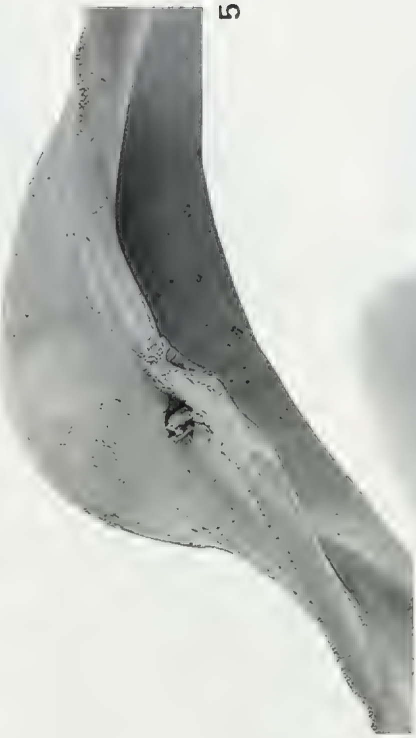
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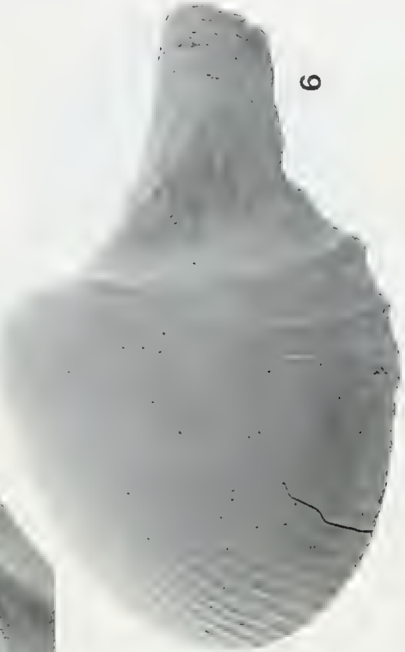
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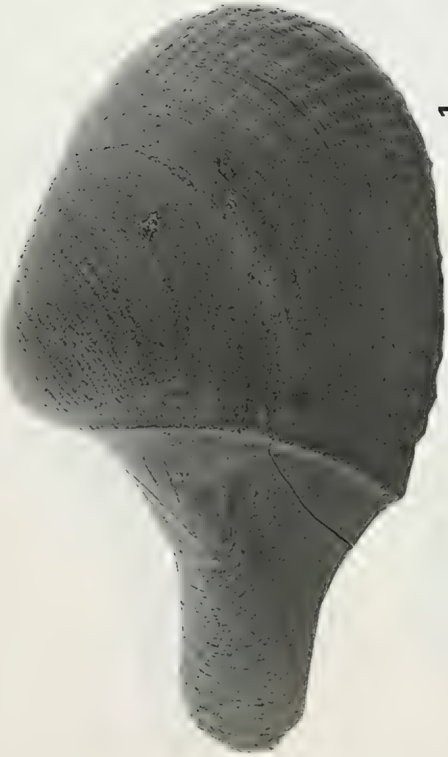
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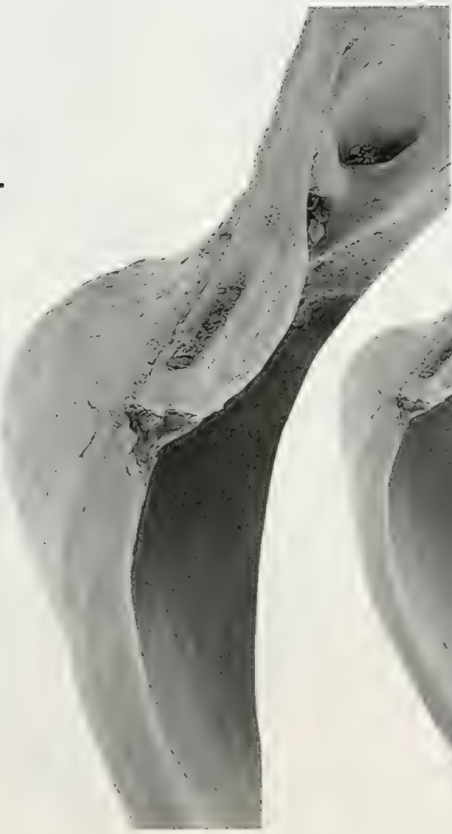
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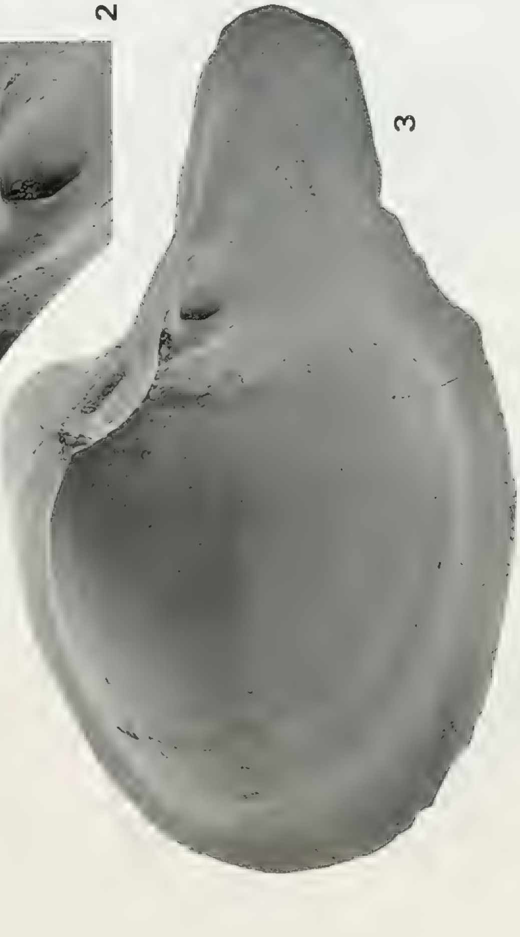
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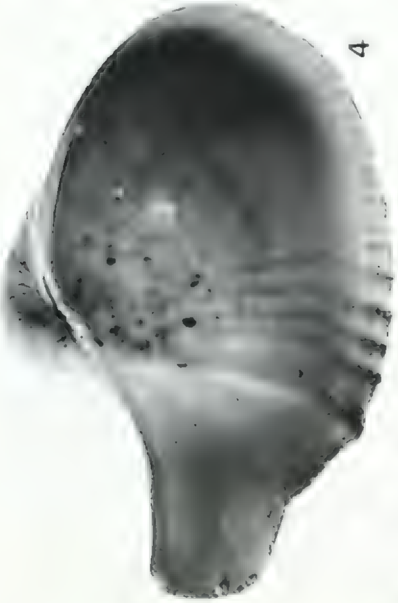
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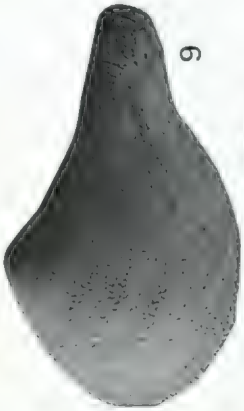
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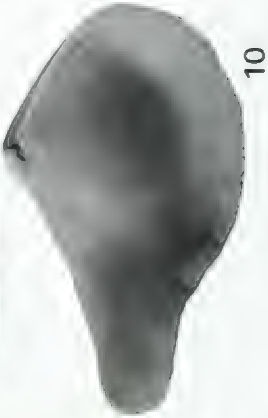
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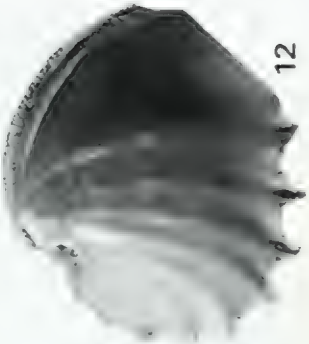
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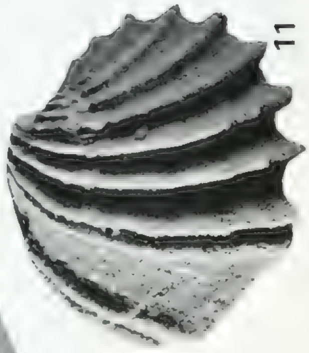
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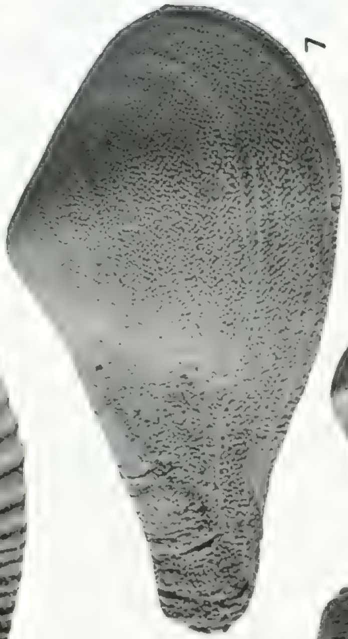
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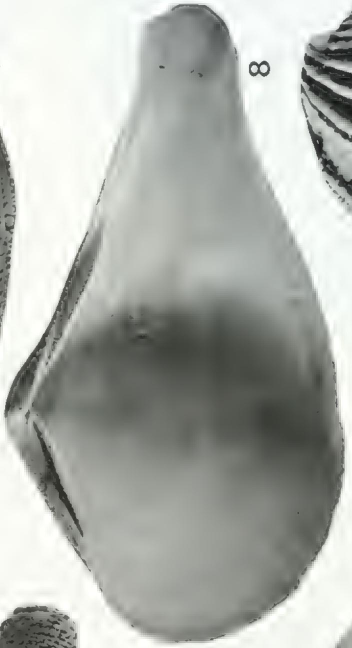
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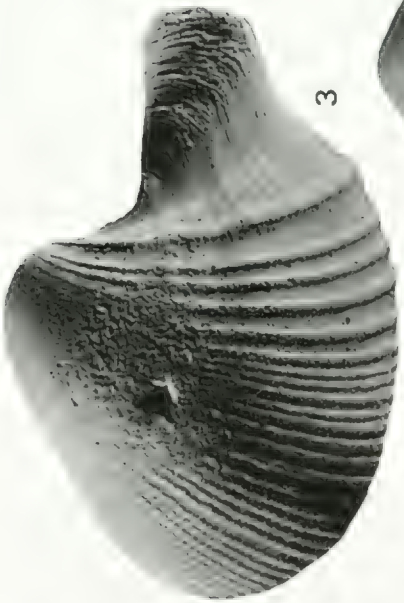
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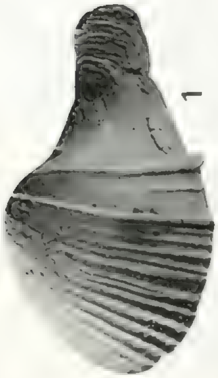
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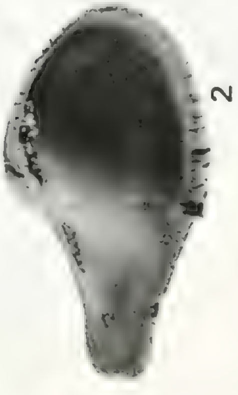
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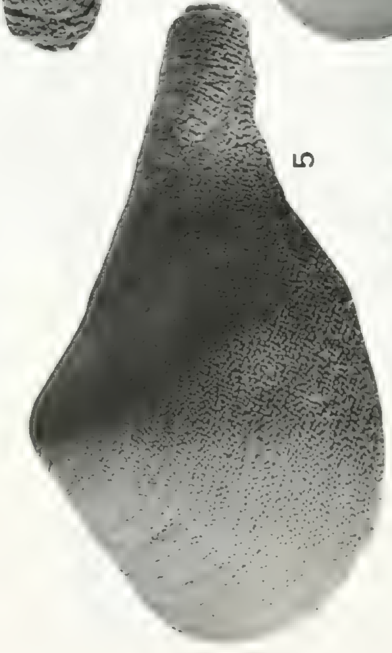
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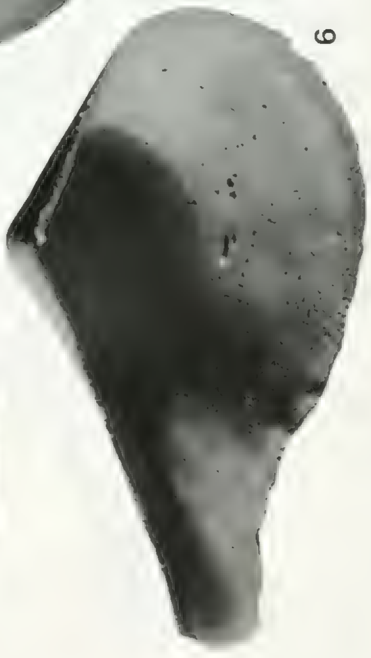
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EXPLANATION OF PLATE 2

Figure — Page

1–4. *Cardiomya (Cardiomya) islahispaniolae* (Maury, 1917) 42

1, 2. Holotype of *Cuspidaria ornatior* Pilsbry and Johnson, 1917. ANSP 2790. "Santo Domingo". Left valve. 1. Exterior; 2. Interior. Length 5.0 mm; height 2.9 mm.

3, 4. Holotype of *Cuspidaria gabbi* Pilsbry and Johnson, 1917. ANSP 2791. "Santo Domingo". Left valve. 3. Exterior; 4. Interior. Length 8.0 mm; height 5.3 mm.

5–8. *Plectodon scaber* Carpenter, 1864. 45

5, 6. USNM 63943. Catalina Island, California; 16 fms., mud. Left valve. 5. Exterior; 6. Interior. Length 17.6 mm; height 9.9 mm.

7, 8. USNM 63943. Catalina Island, California; 16 fms., mud. Right valve. 7. Exterior; 8. Interior. Length 17.4 mm; height 9.2 mm.

9, 10. *Plectodon granulatus* (Dall, 1881) 45

Lectotype. USNM 63193. Off Sombrero Island, Leeward Islands, Lesser Antilles; 72 fms. Left valve. 9. Exterior; 10. Interior. Length 11.3 mm; height 6.7 mm.

11, 12. *Trigonulina pacifica*, new species. 50

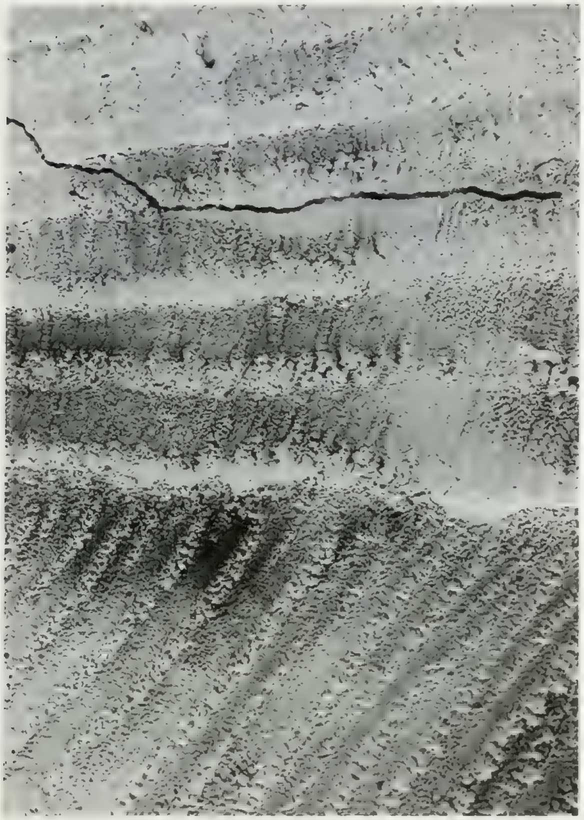
Holotype. LACM 2718. Locality LACM 65-6.22: 0.4–0.7 miles 110 to 132 degrees T From Ship Rock, Santa Catalina Island, California Channel Islands, California (33°27′N, 118°30′W). Depth: 82 m. Right valve. 11. Exterior; 12. Interior. Length 4.8 mm; height 4.2 mm.

EXPLANATION OF PLATE 3

Figure		Page
1–5	*Cardiomya (Bowdenia) distira* (Dall, 1903)	44

1–4. NMB G 14139. NMB locality 15846 Río Gurabo, Dominican Republic; latest Miocene part of Gurabo Formation. Incomplete right valve. 1. Exterior; 2. Enlargement of sculpture, ×120; 3. Interior; 4. Enlargement of hinge, ×60. Length 2.7 mm; height 2.2 mm.

5. NMB G 14140. NMB locality 10635: Bowden, Jamaica; type locality of Bowden Formation (early Pliocene). Interior of right valve. Length 3.2 mm; height 2.0 mm.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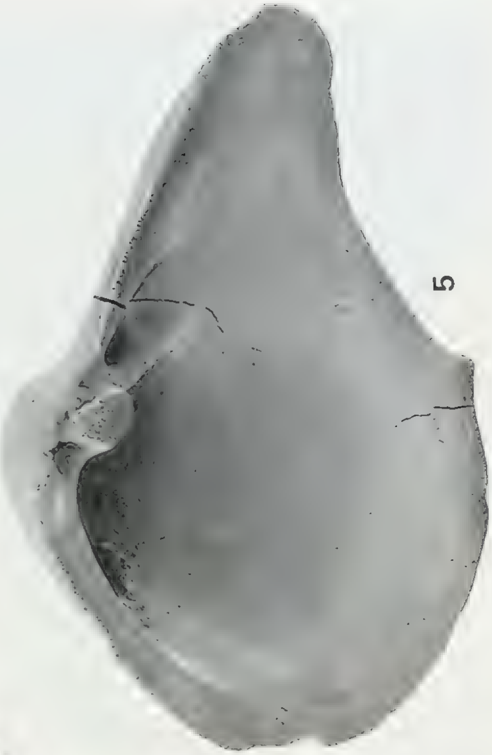
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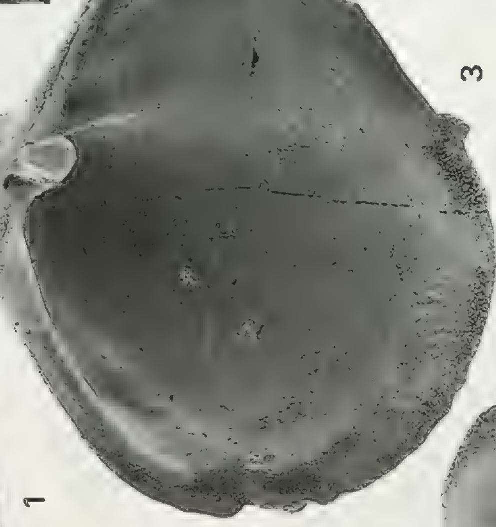
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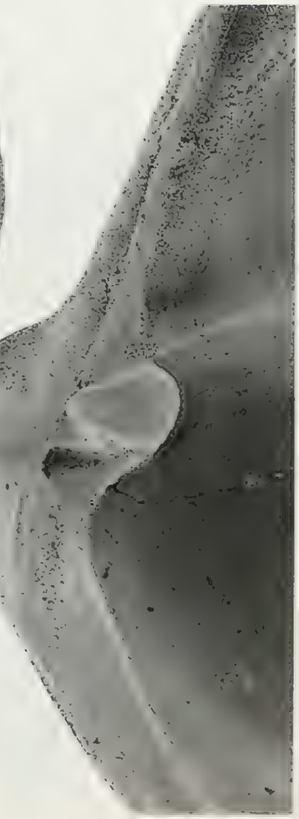
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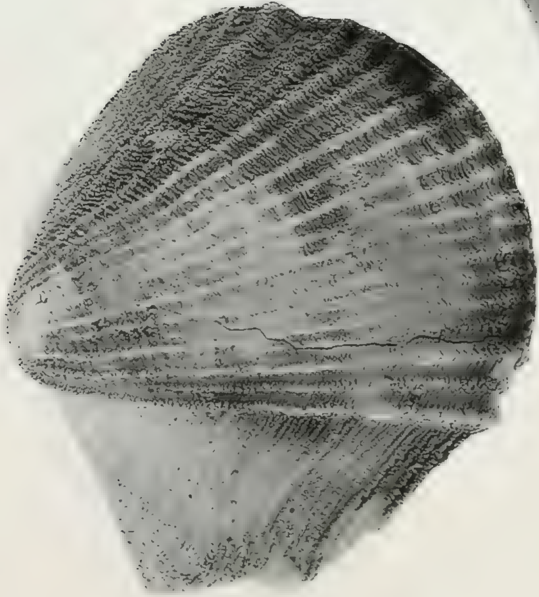
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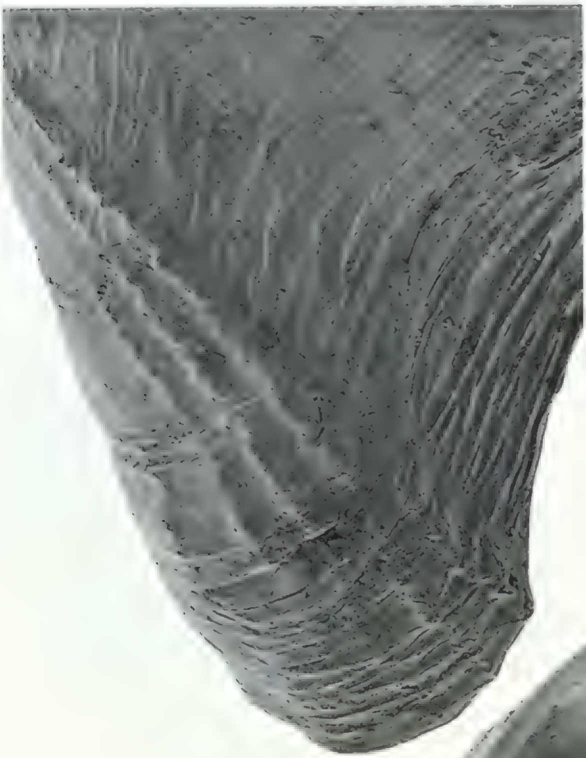
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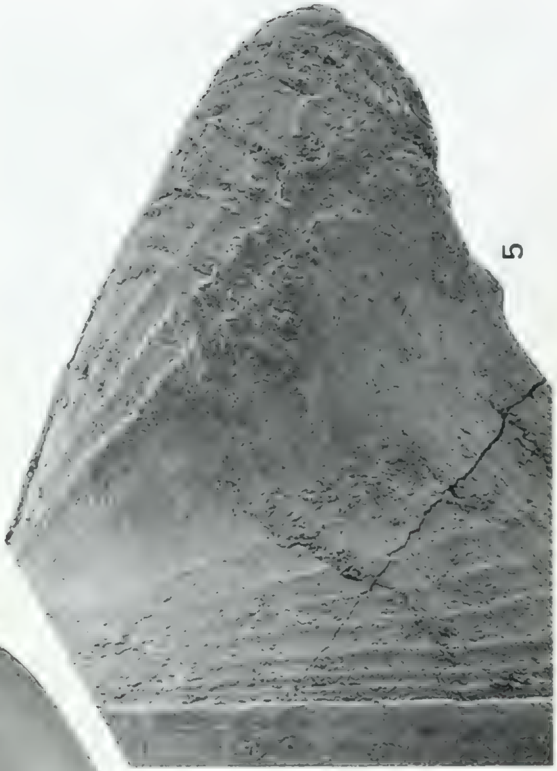
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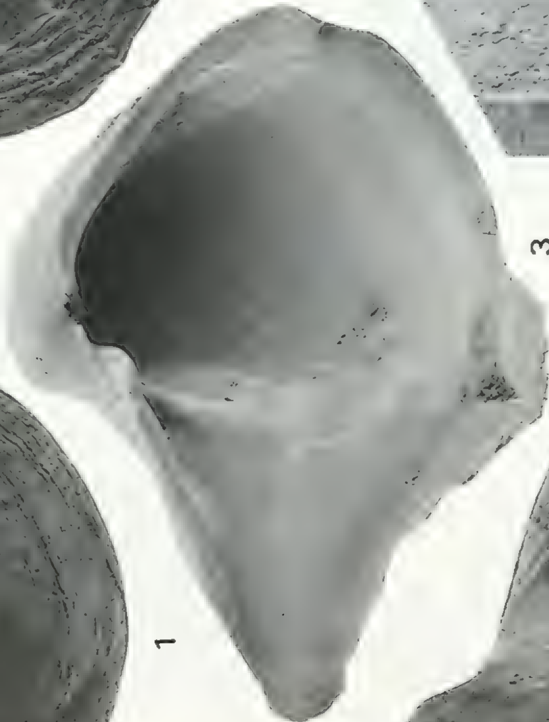
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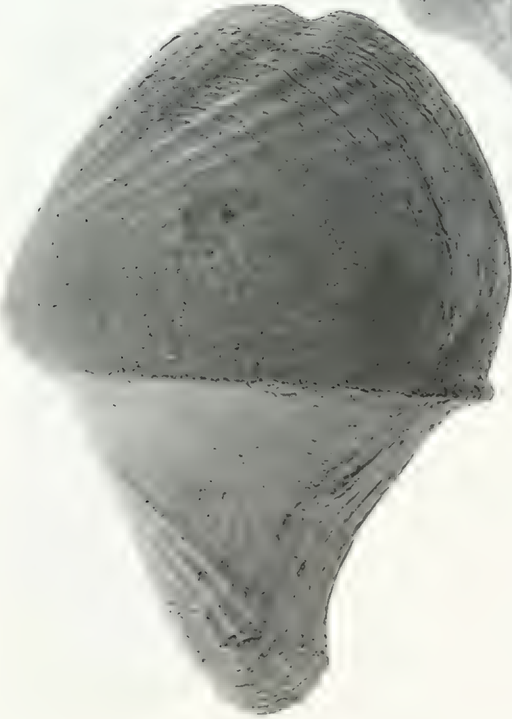
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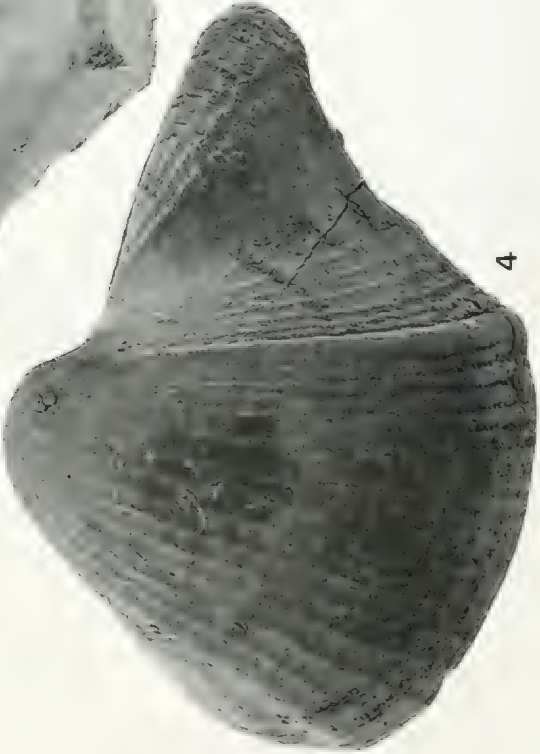
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EXPLANATION OF PLATE 4

Figure ... Page

1–5. *Cardiomya (Bowdenia) distira* (Dall, 1903) ... 44

All specimens from NMB locality 10635: Bowden, Jamaica; type locality of Bowden Formation (early Pliocene).

1, 2. NMB G 14141. Right valve. 1. Exterior; 2. Enlargement of rostrum, ×90. Length 3.0 mm; height 2.0 mm.

3. NMB G 14142. Interior of left valve. Length 2.9 mm; height 2.3 mm.

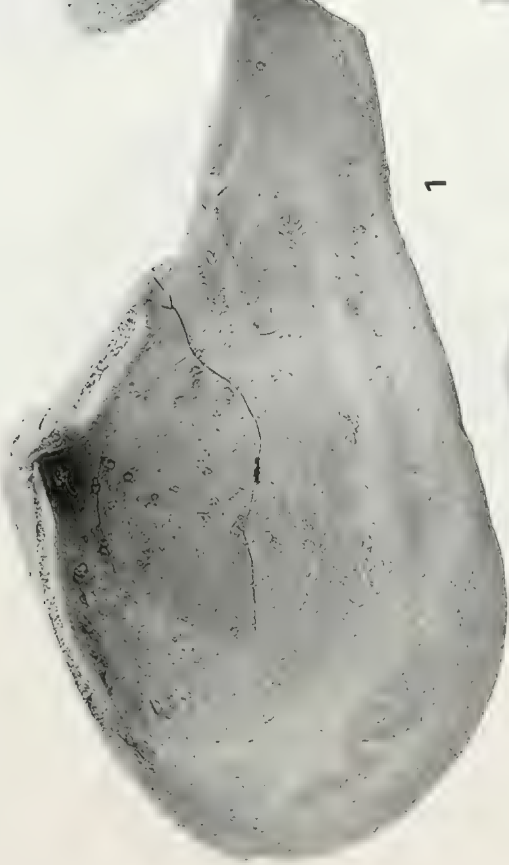
4, 5. NMB G 14143. Left valve. 4. Exterior; 5. Enlargement of rostrum, ×65. Length 3.3 mm; height 2.3 mm.

EXPLANATION OF PLATE 5

Figure Page

1–4. *Plectodon granulatus* (Dall, 1881) 46

NMB G 14138. NMB locality 16857; Río Cana, Dominican Republic; Cercado Formation (late Miocene). Right valve. 1. Interior; 2. Enlargement of hinge, ×20; 3. Exterior; valve broken during handling for SEM photography; 4. Enlargement of sculpture, ×60. Length 10.6 mm; height 6.4 mm.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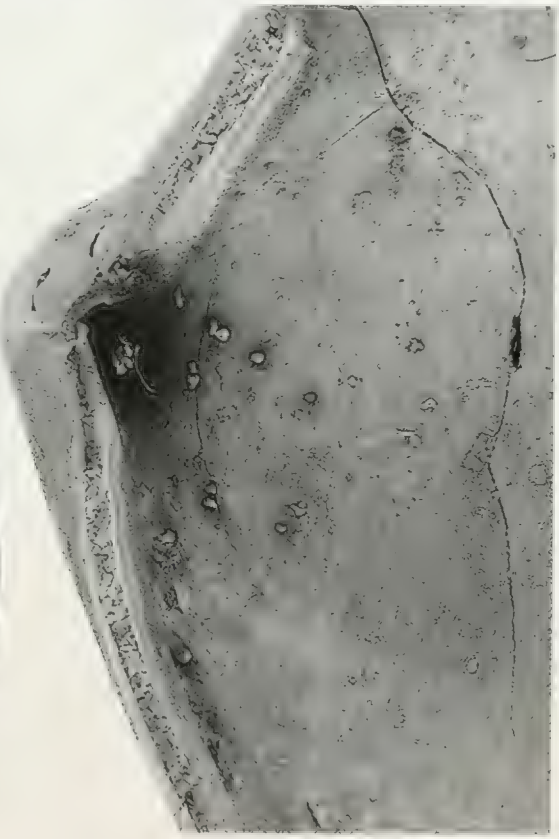
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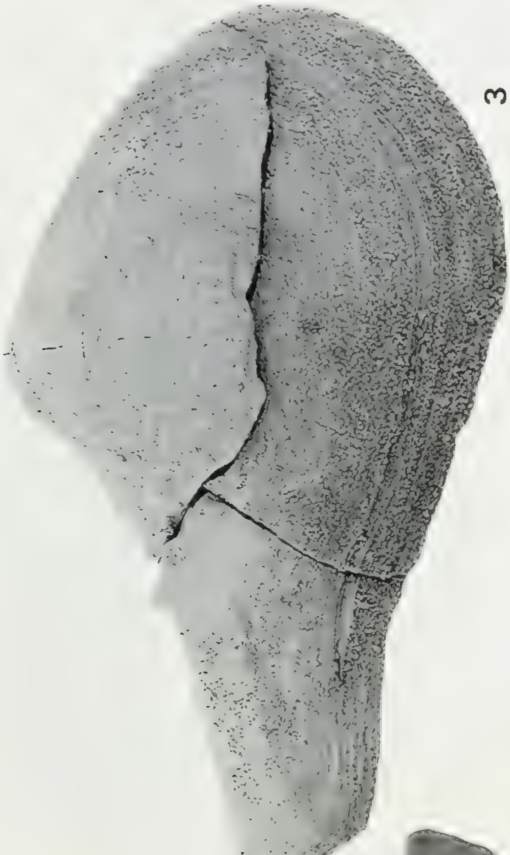
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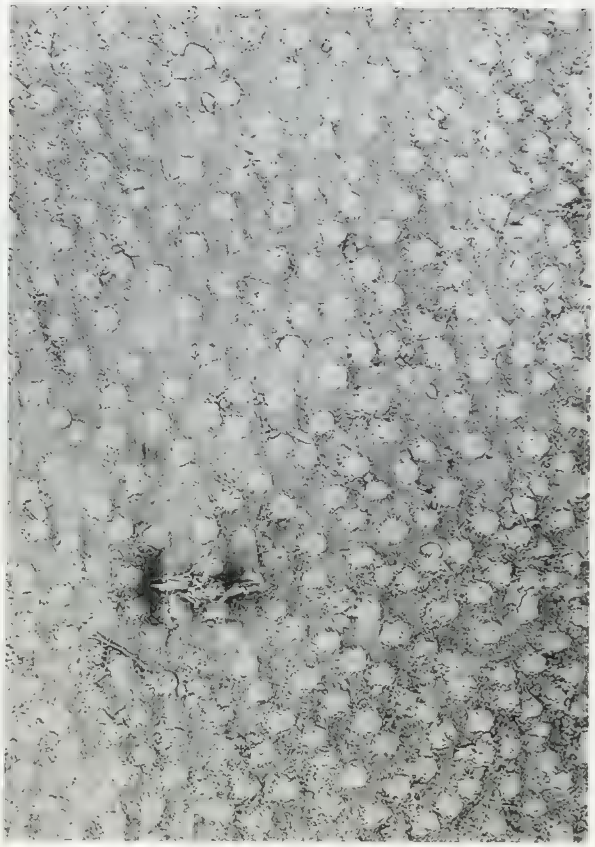
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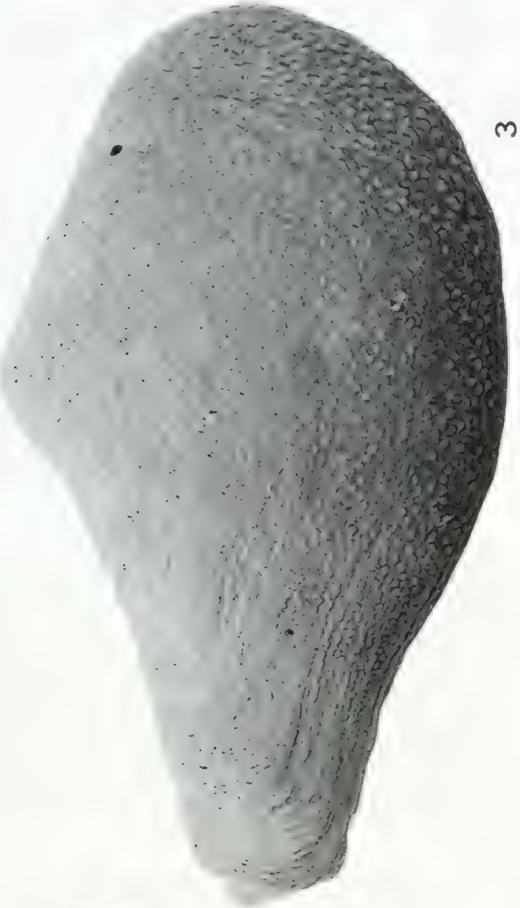

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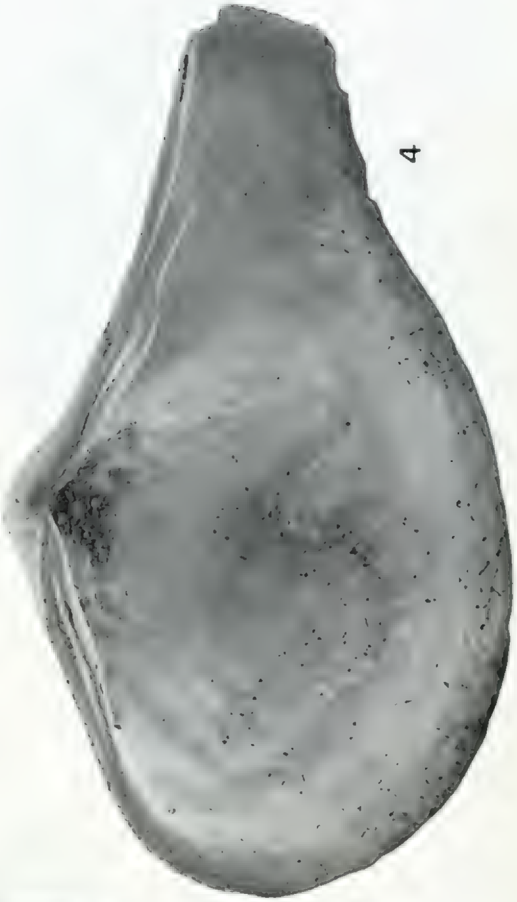

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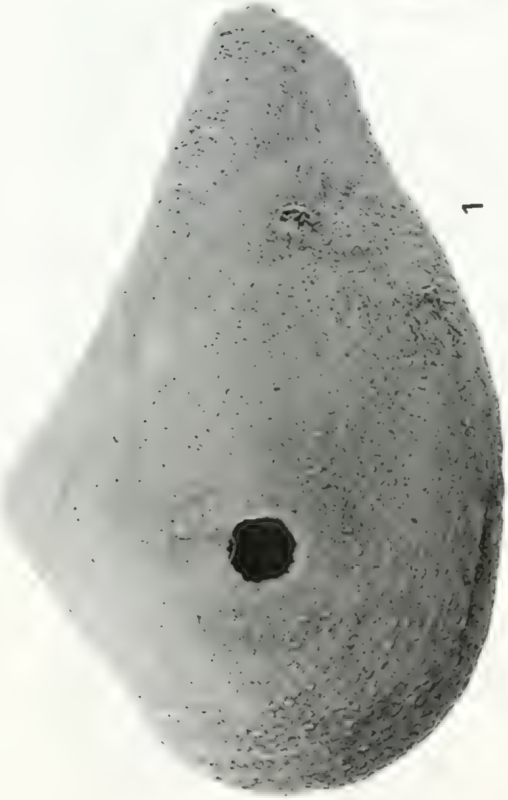

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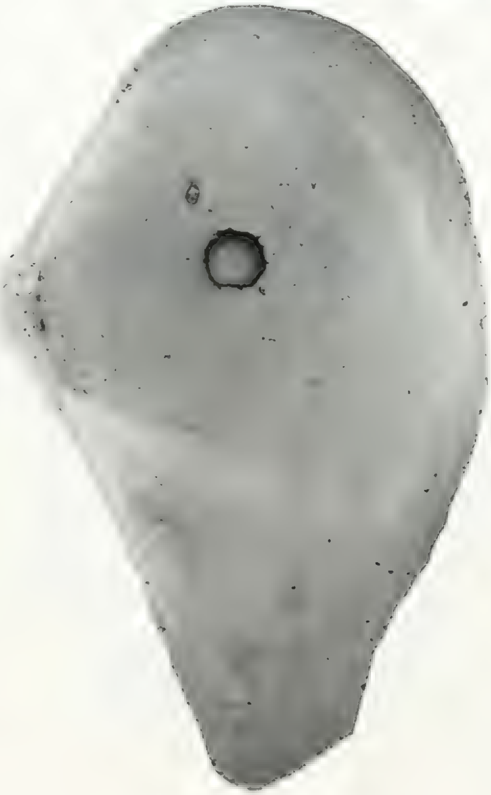

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EXPLANATION OF PLATE 6

Figure | Page
1–4. *Plectodon granulatus* (Dall, 1881) 46
USNM 94214. Recent. Station 2648: off Cape Florida, 84 fms., sand.
1, 2. Left valve. 1. Exterior; 2. Interior. Length 8.8 mm; height 5.6 mm.
3, 4. Right valve. 3. Exterior; 4. Interior. Length 11.5 mm; height 6.5 mm.

EXPLANATION OF PLATE 7

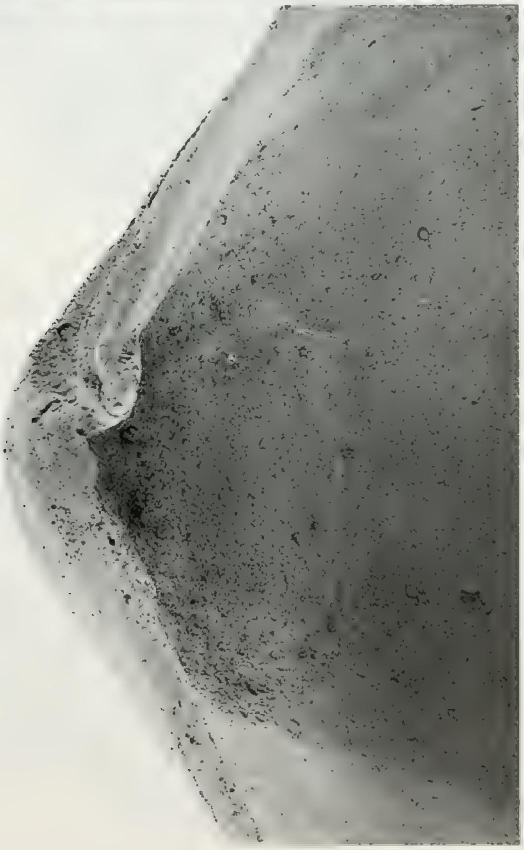
Figure | Page

1-4. *Plectodon granulatus* (Dall, 1881) . . . 46

USNM 94214. Recent. Station 2648: off Cape Florida, 84 fms., sand.

1. Enlargement of left hinge (×30) of specimen shown on Plate 6, figure 2.
2. Enlargement of right hinge (×20) of specimen shown on Plate 6, figure 4.

3, 4. Enlargement of sculpture of right valve shown on Plate 6, figure 3. 3. Near center of shell disc, ×60; 4. Towards rostrum, ×50



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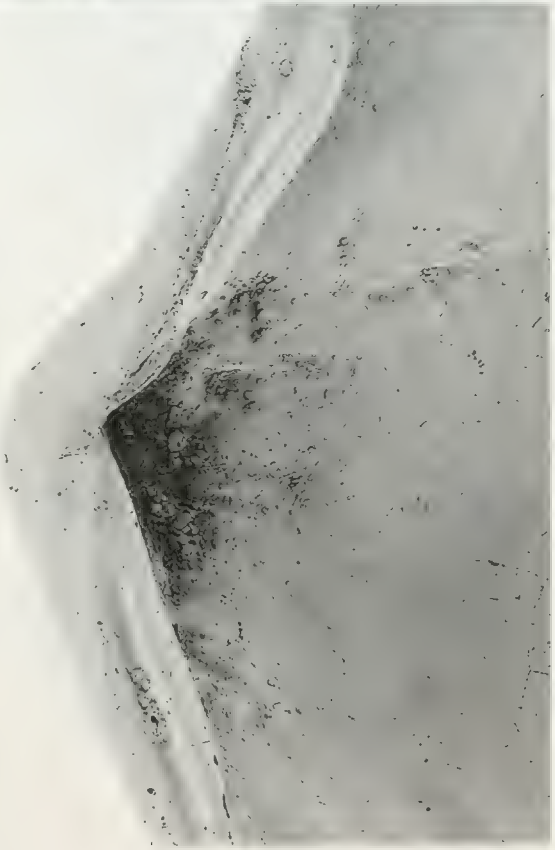

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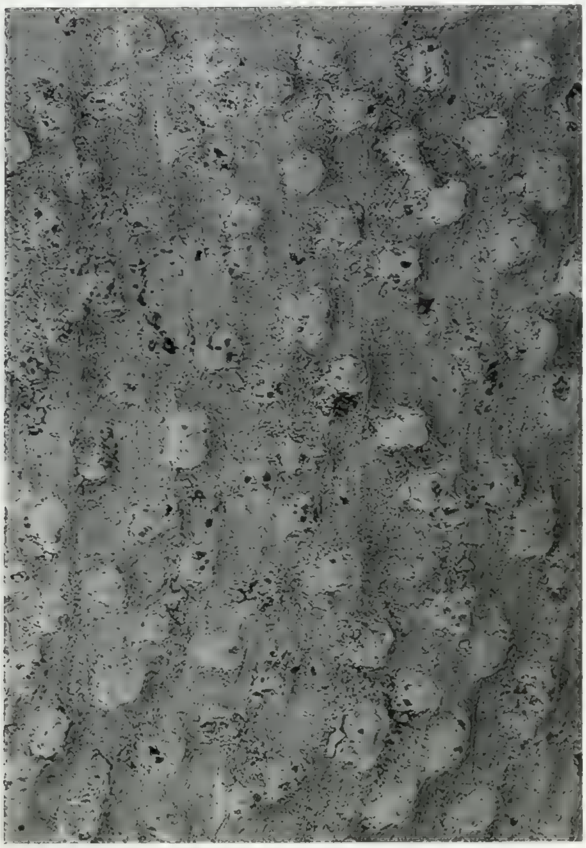

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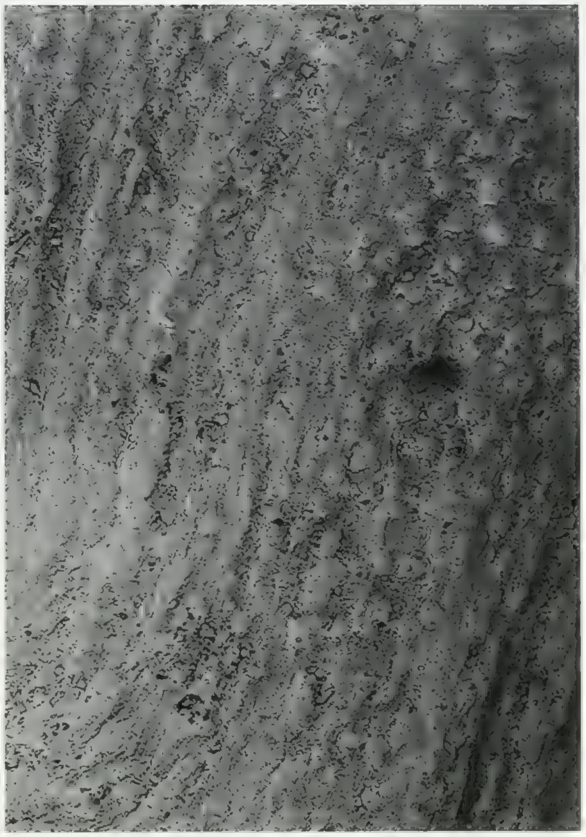

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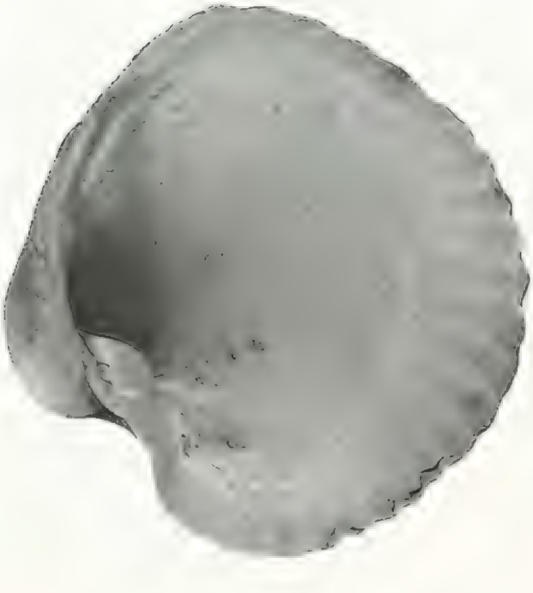

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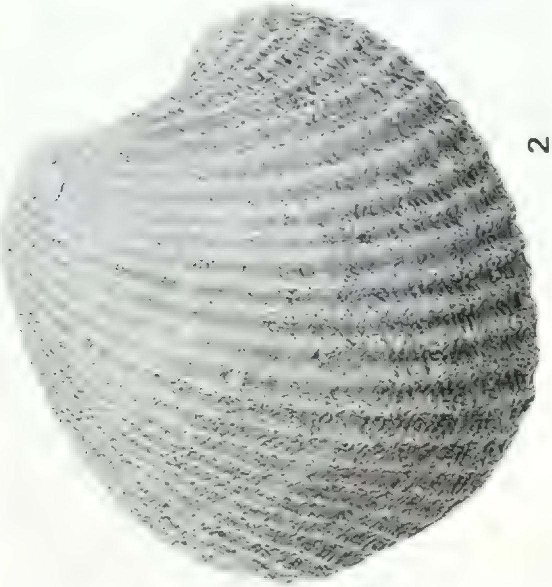

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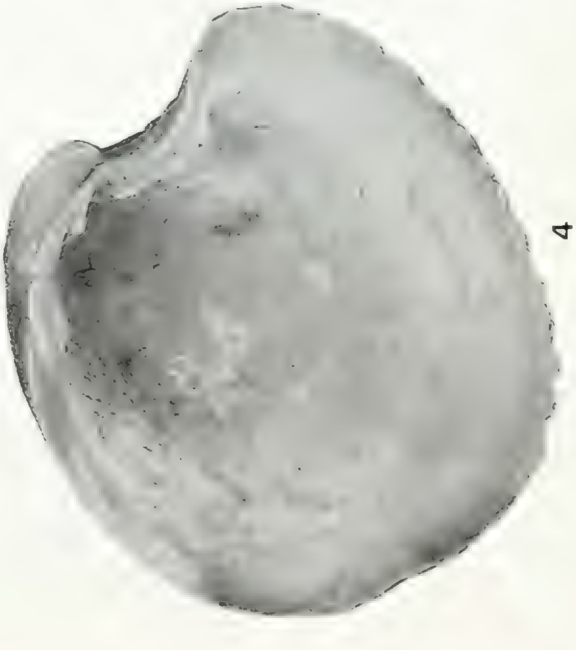

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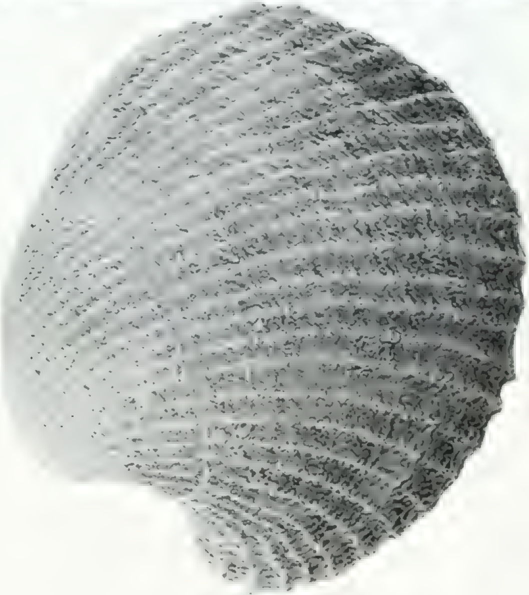

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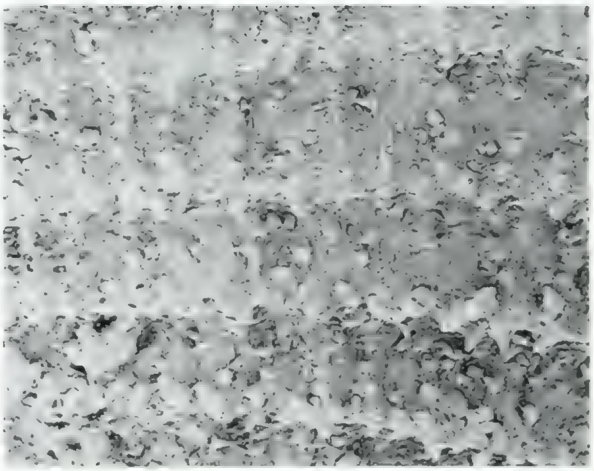

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EXPLANATION OF PLATE 8

Figure		Page
1–6.	*Haliris fischeriana* (Dall, 1881)	47

USNM 444416. Recent. Eolis Station 370: off Ajax Reef, Florida, 70–90 fms.

1. Interior of right valve. Length 6.0 mm; height 5.6 mm.
2, 3. Exterior of right valve. Length 6.1 mm; height 5.7 mm. 3. Enlargement of sculpture, ×50.
4. Interior of left valve. Length 6.1 mm; height 5.6 mm.
5, 6. Exterior of left valve. Length 6.4 mm; height 5.8 mm. 6. Enlargement of sculpture, ×50.

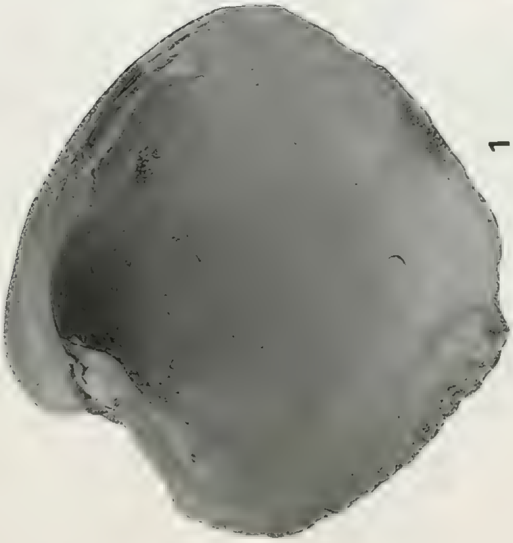
EXPLANATION OF PLATE 9

Figure — Page

1–6. *Haliris jamaicensis* (Dall, 1903) 47

1–3. NMB G 14148. NMB locality: 15832: Río Gurabo, Dominican Republic; middle Pliocene part of Mao Formation. Right valve. 1. Interior; 2. Exterior; 3. Enlargement of sculpture, ×60. Length 4.3 mm; height 4.1 mm.

4–6. NMB G 14149. NMB locality 10635. Bowden, Jamaica; Bowden Formation (early Pliocene). Right valve. 4. Exterior; 5. Interior; 6. Enlargement of hinge, ×40. Length 4.3 mm; height 3.9 mm.



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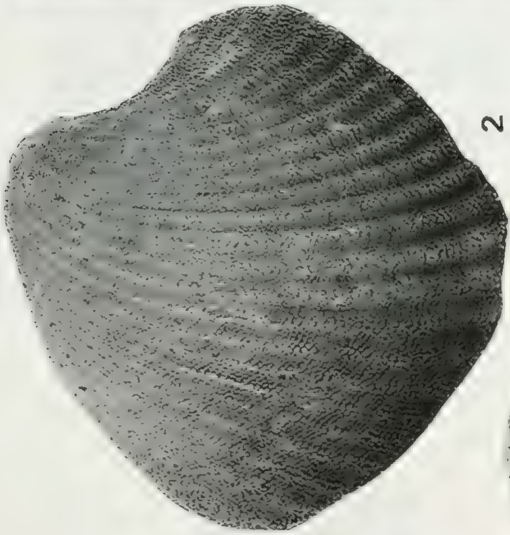

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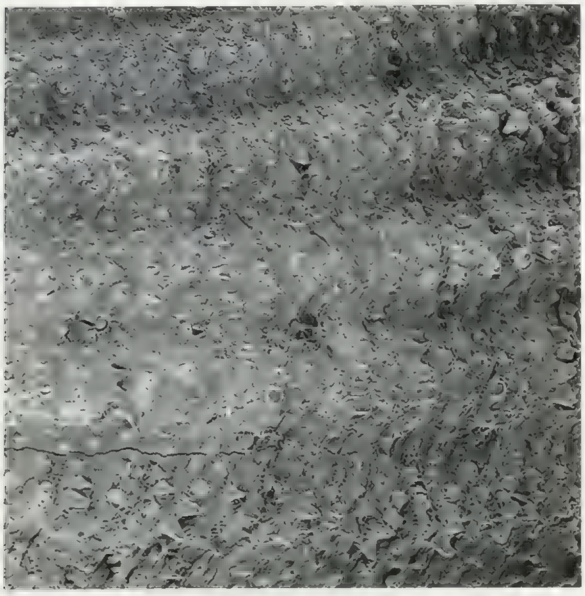

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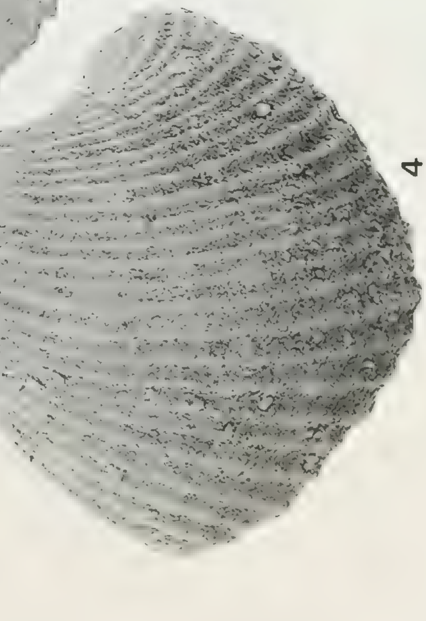

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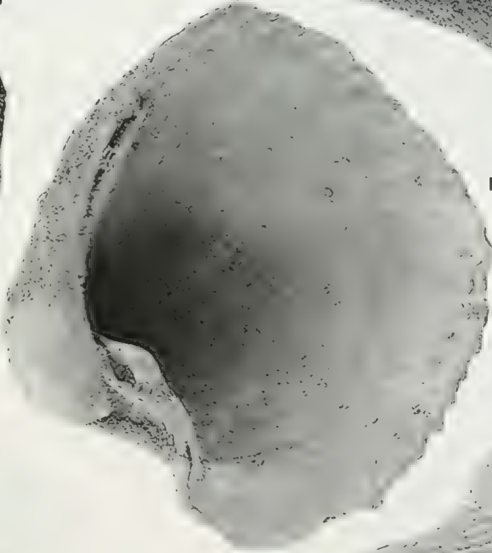

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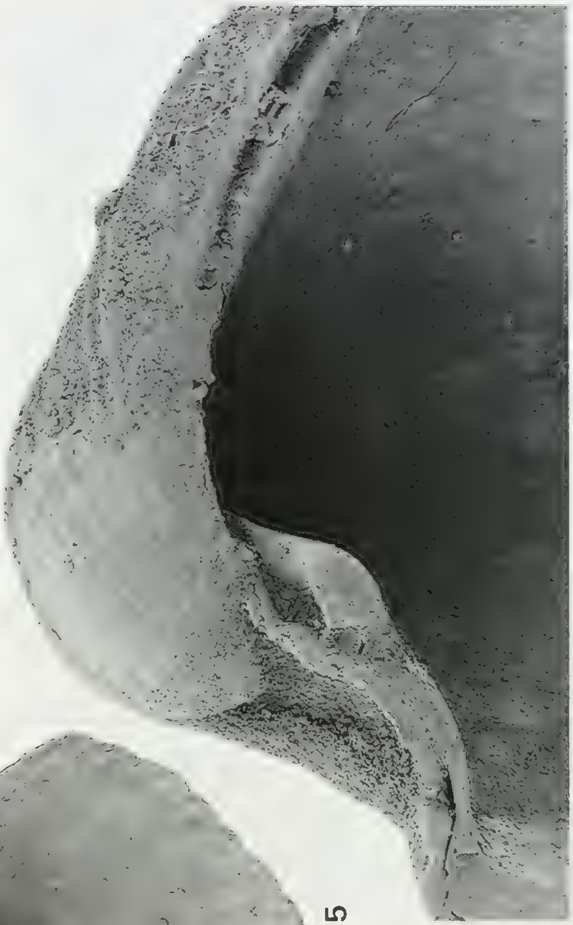

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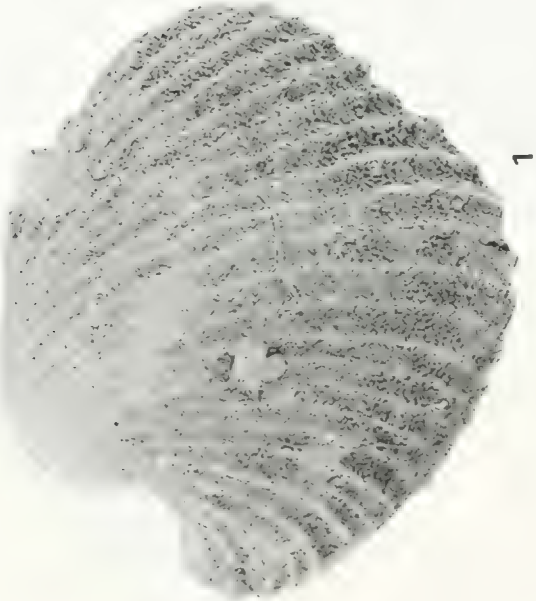

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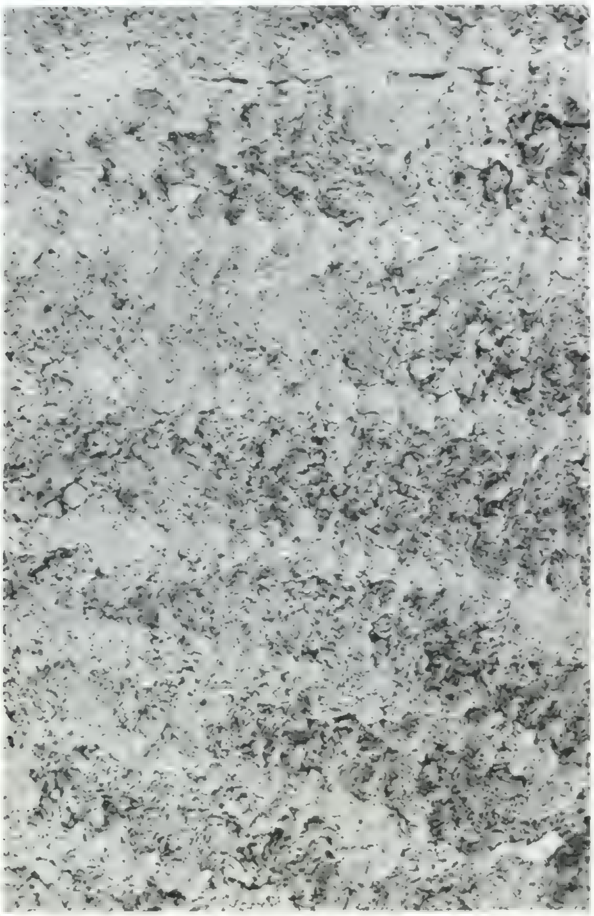

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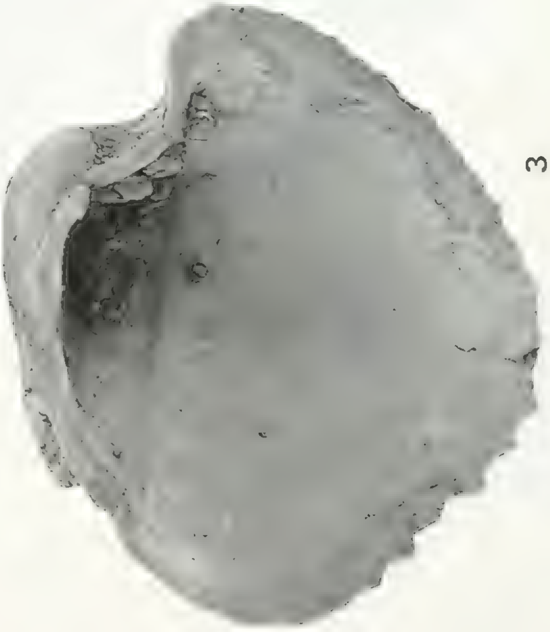

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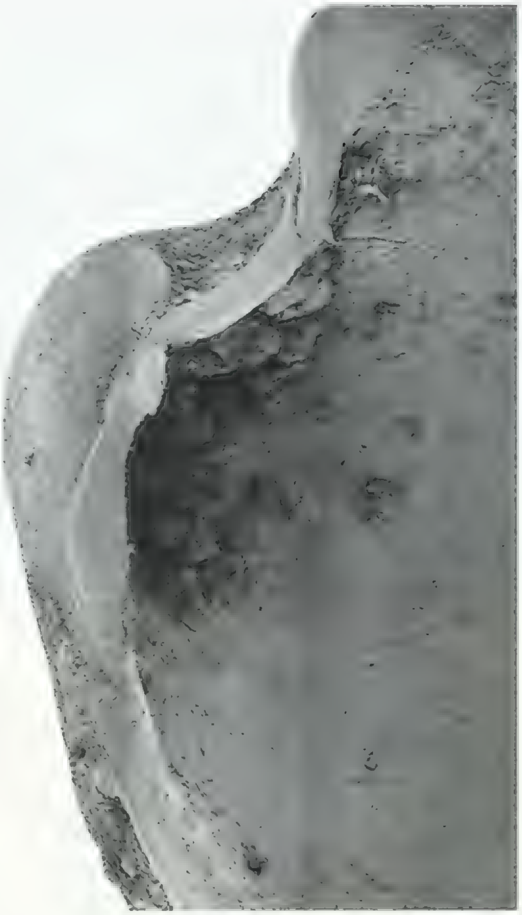

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EXPLANATION OF PLATE 10

Figure		Page
1–4.	*Haliris jamaicensis* (Dall, 1903). NMB G 14158. NMB locality 10635: Bowden, Jamaica; Bowden Formation (early Pliocene). Left valve. 1. Exterior; 2. Enlargement of sculpture, ×100; 3. Interior; 4. Enlargement of hinge, ×50. Length 3.2 mm; height 2.6 mm.	47

EXPLANATION OF PLATE 11

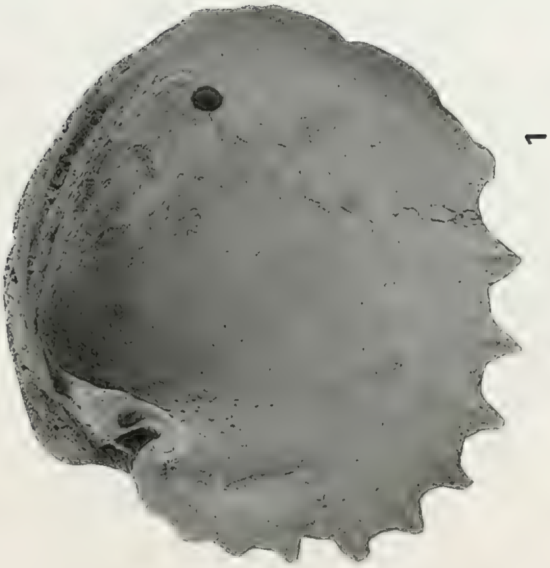
Figure — Page

1–4. *Trigonulina ornata* d'Orbigny, 1842 49

USNM 444479. Recent. Eolis Station 178: off Fowey Light, Florida, 68 fms.

1, 2. Interior of right valve. Length 4.2 mm; height 3.8 mm. 2. Enlargement of hinge, ×45.

3, 4. Interior of left valve. Length 3.4 mm; height 3.2 mm. 4. Enlargement of hinge, ×55



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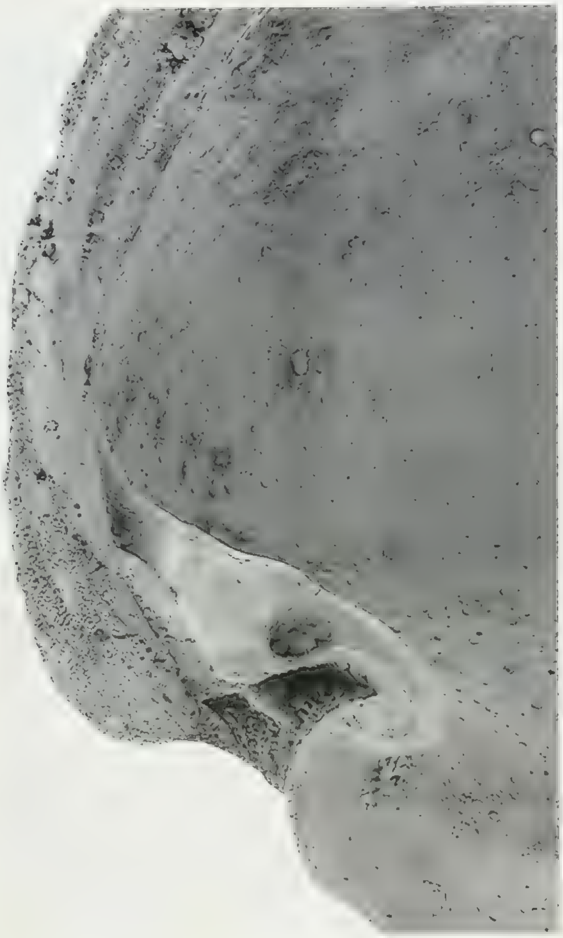

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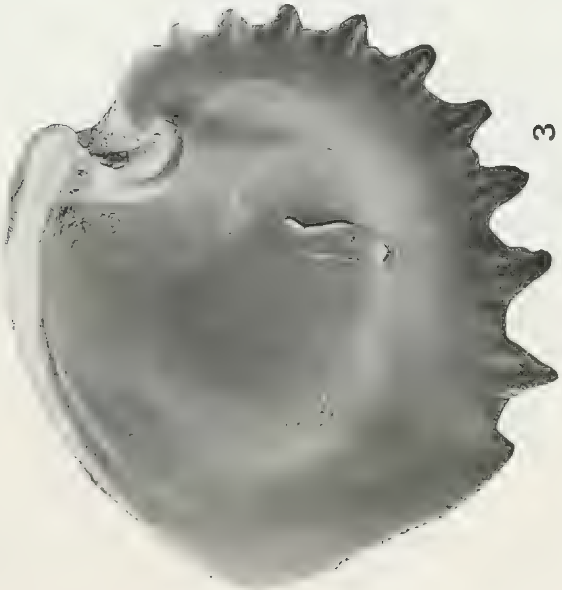

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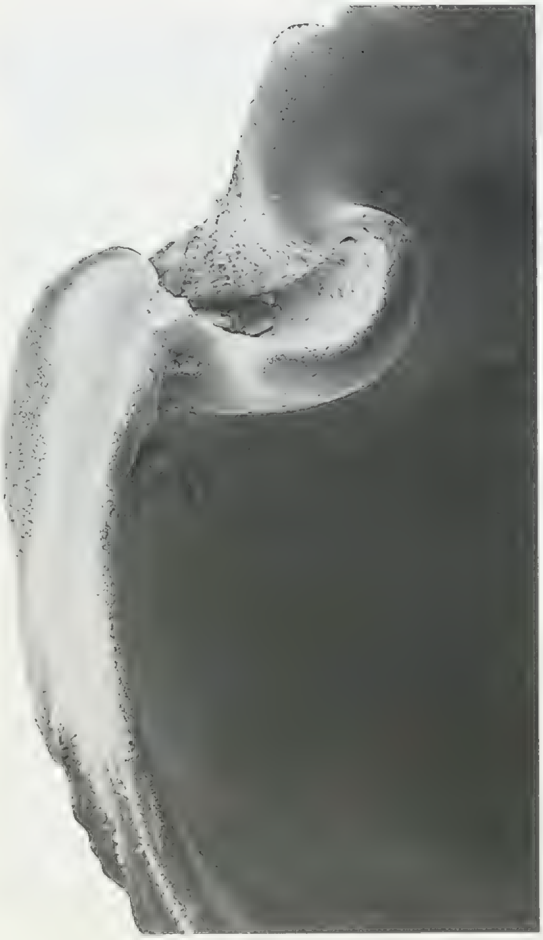

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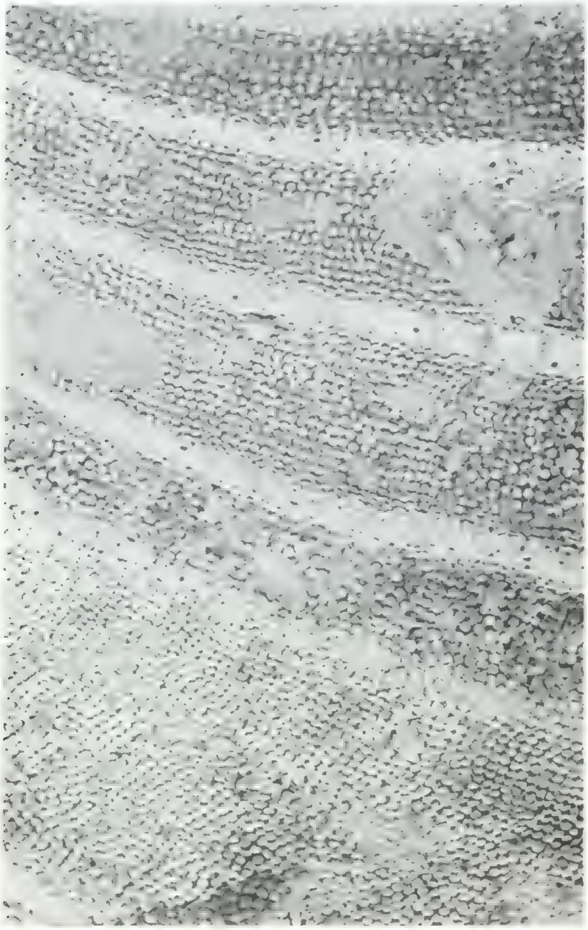
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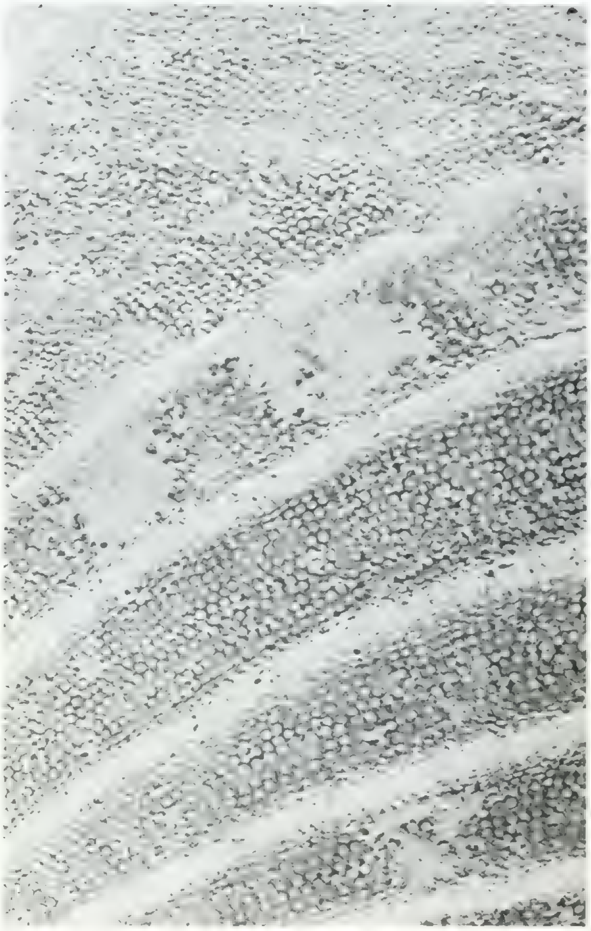
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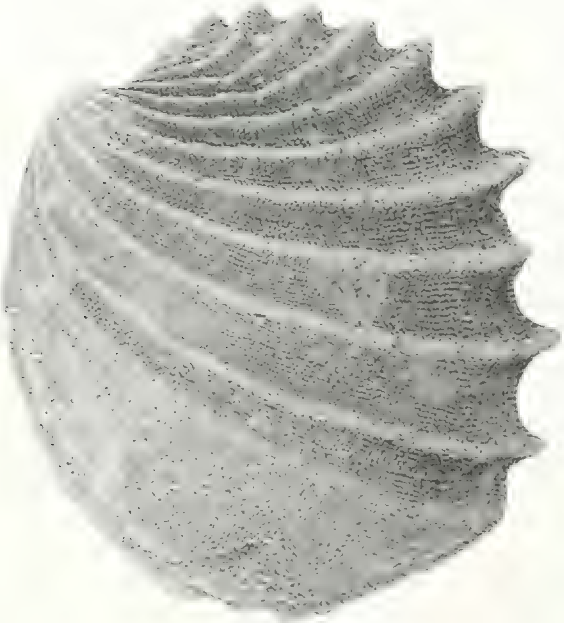
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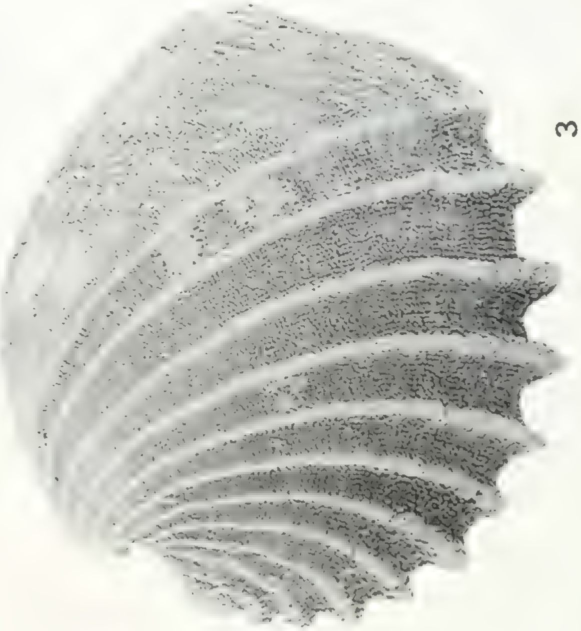
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EXPLANATION OF PLATE 12

Figure .... Page

1–4. *Trigonulina ornata* d'Orbigny, 1842. 49

USNM 444479. Recent. Eolis Station 178: off Fowey Light, Florida, 68 fms.

1, 2. Exterior of right valve. Length 3.7 mm; height 3.3 mm. 2. Enlargement of sculpture, ×50.

3, 4. Exterior of left valve. Length 4.0 mm; height 3.6 mm. 4. Enlargement of sculpture, ×50.

EXPLANATION OF PLATE 13

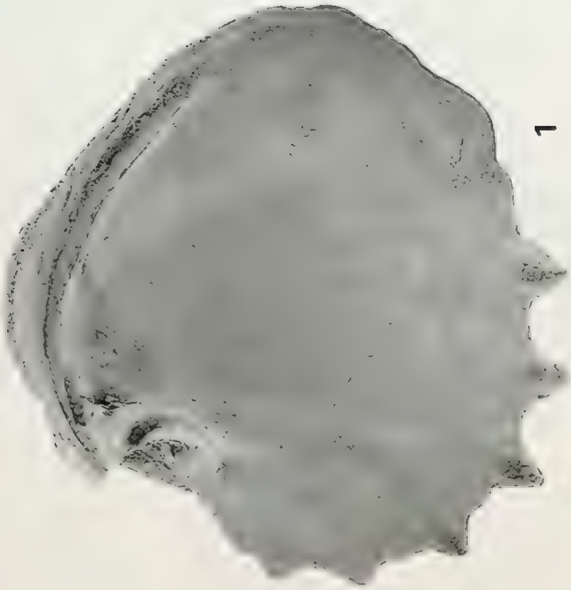
Figure Page

1–4 *Trigonulina pacifica*, new species 50

USNM 211469. Recent, off La Paz, Baja California, Mexico; 9½–10 fms.

1, 2. Interior of right valve. Length 4.8 mm; height 4.7 mm. 2. Enlargement of hinge, ×35.

3, 4. Interior of left valve. Length 4.7 mm; height 4.3 mm. 4. Enlargement of hinge, ×40.



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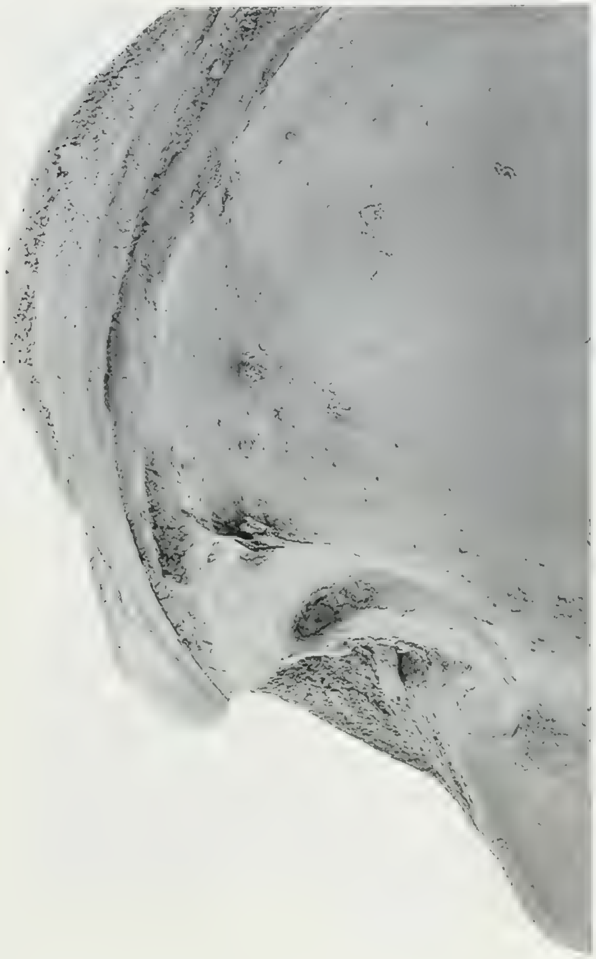

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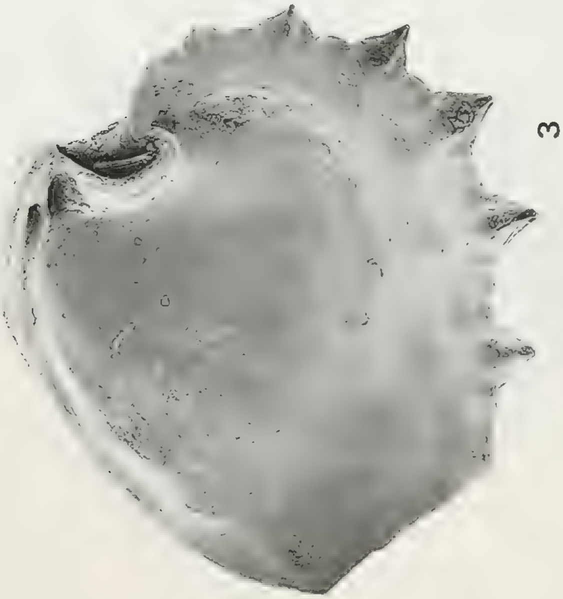

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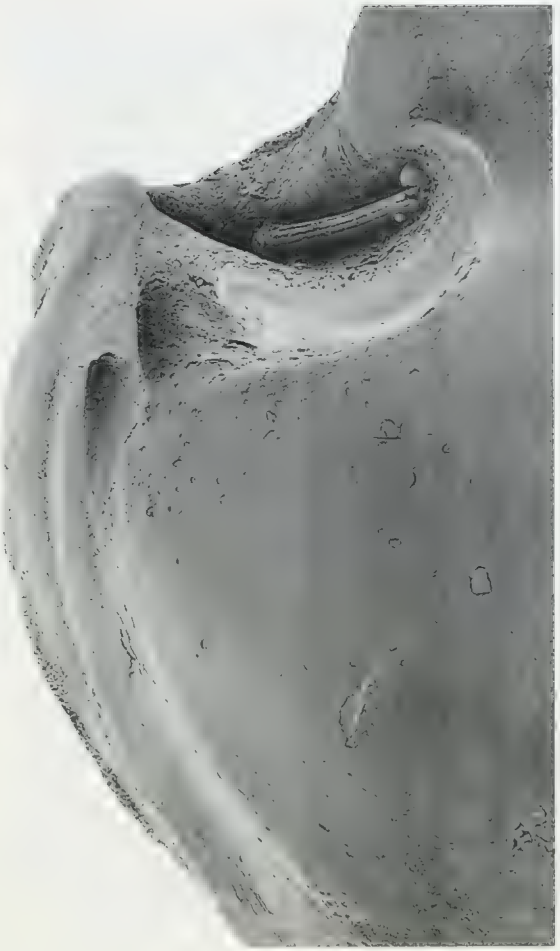

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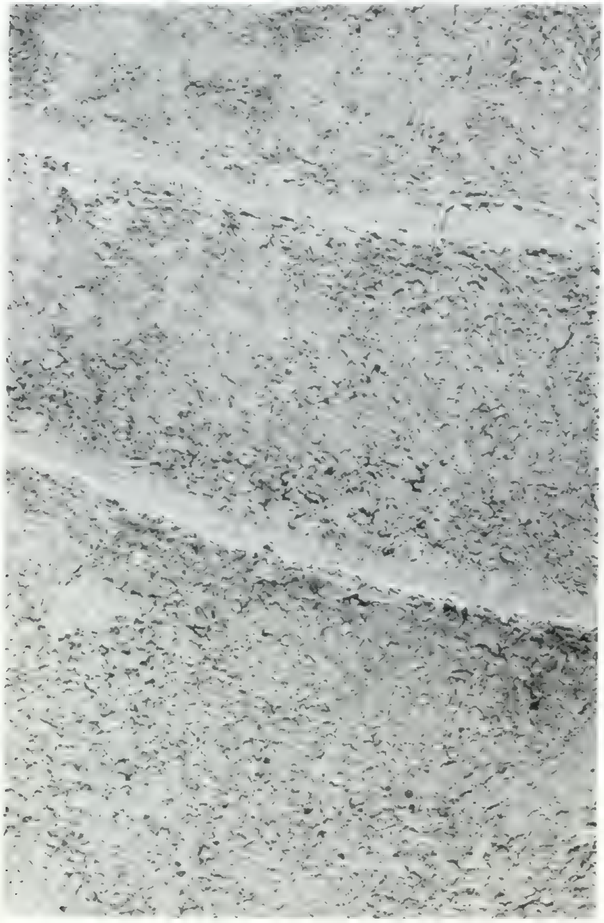
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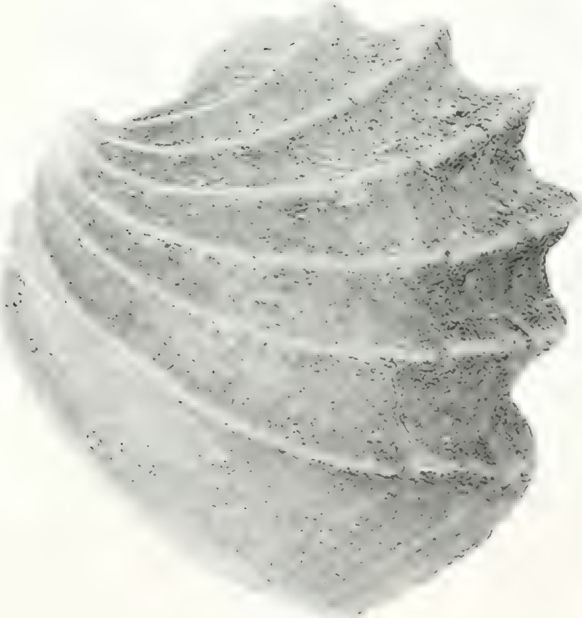
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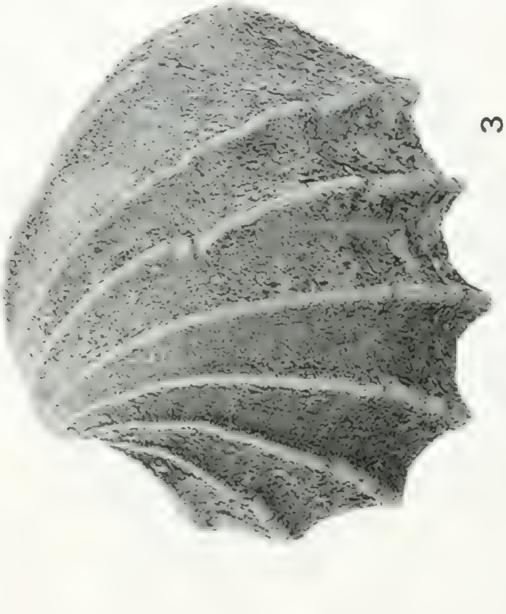

3

EXPLANATION OF PLATE 14

Figure — Page

1–4. *Trigonulina pacifica,* new species. 50

USNM 211469. Recent, off La Paz, Baja California, Mexico; 9½–10 fms.

1, 2. Exterior of right valve. Length 5.1 mm; height 4.9 mm. 2. Enlargement of sculpture, ×50.

3, 4. Exterior of left valve. Length 4.5 mm; height 4.0 mm. 4. Enlargement of sculpture, ×50.

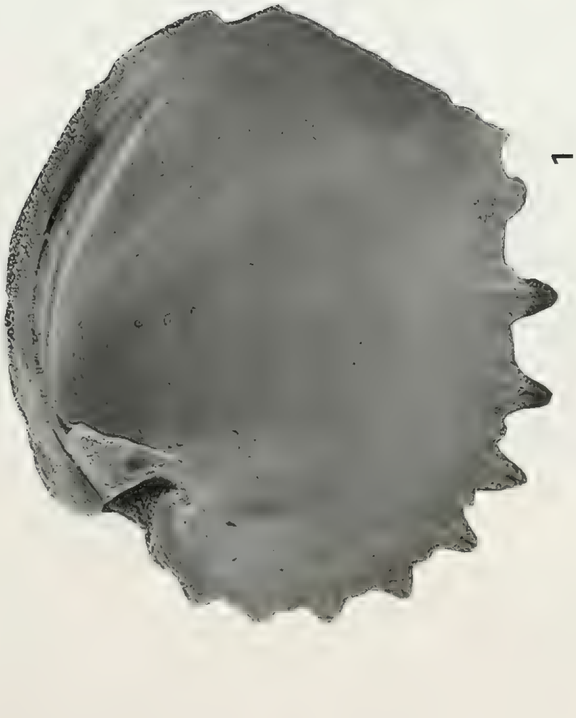
EXPLANATION OF PLATE 15

Figure		Page
1–4.	*Trigonulina bowdenensis* (Dall, 1903). . .	53

NMB locality 15846: Río Gurabo; Gurabo Formation (late Miocene).

1, 2. NMB G 14151. Interior of right valve. Length 3.5 mm; height 3.1 mm. 2. Enlargement of hinge, ×40.

3, 4. NMB G 14153. Interior of left valve. Length 3.3 mm; height 3.0 mm. 4. Enlargement of hinge, ×50.



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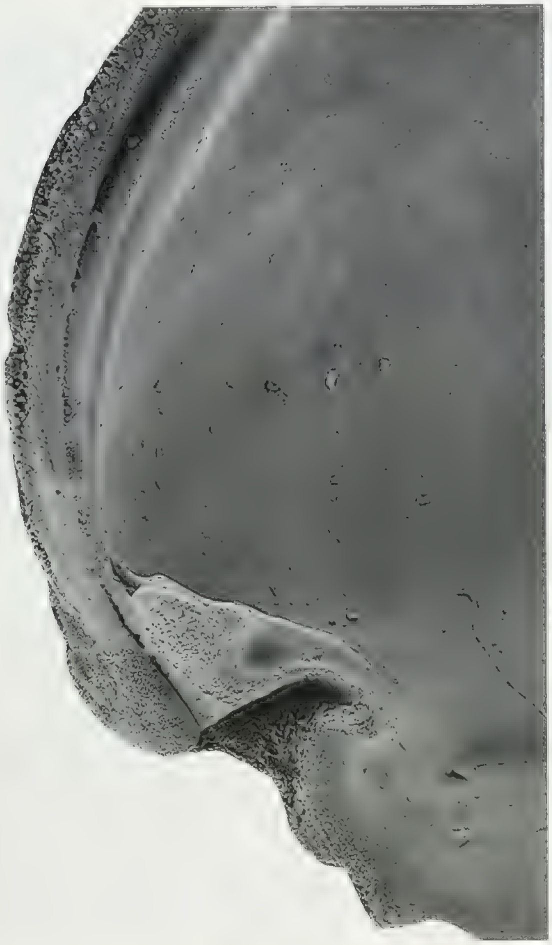

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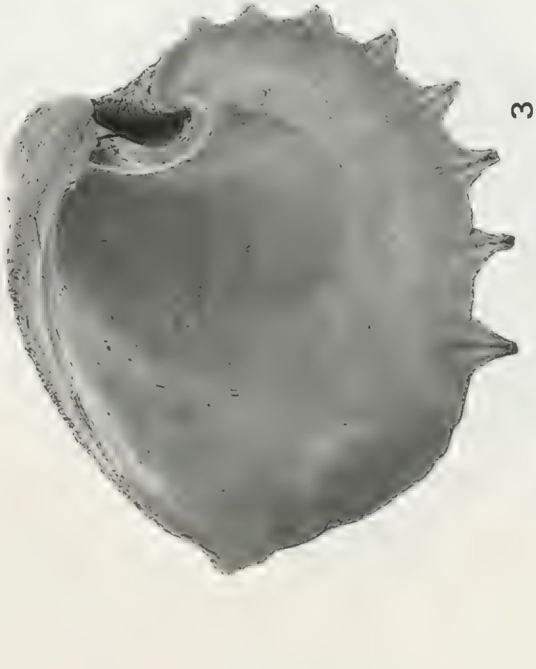

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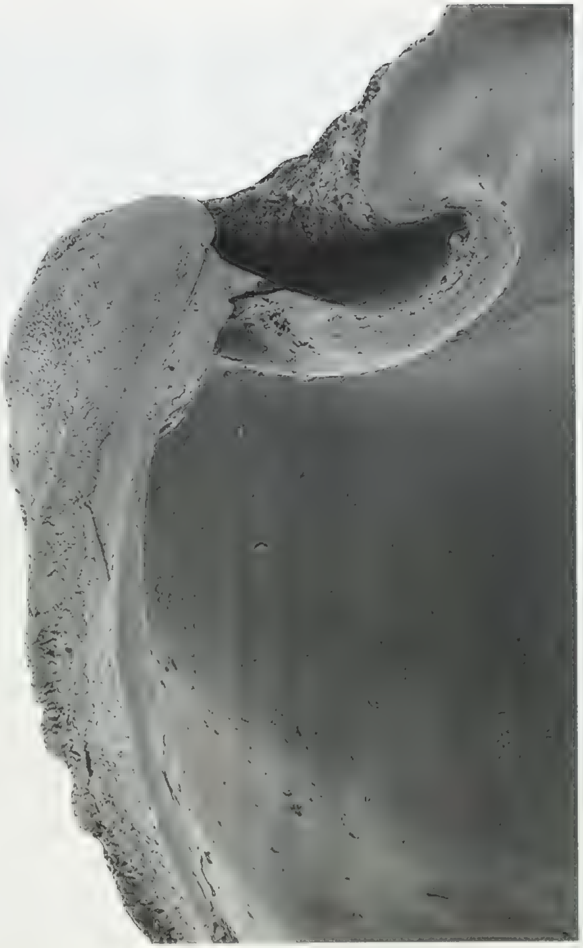

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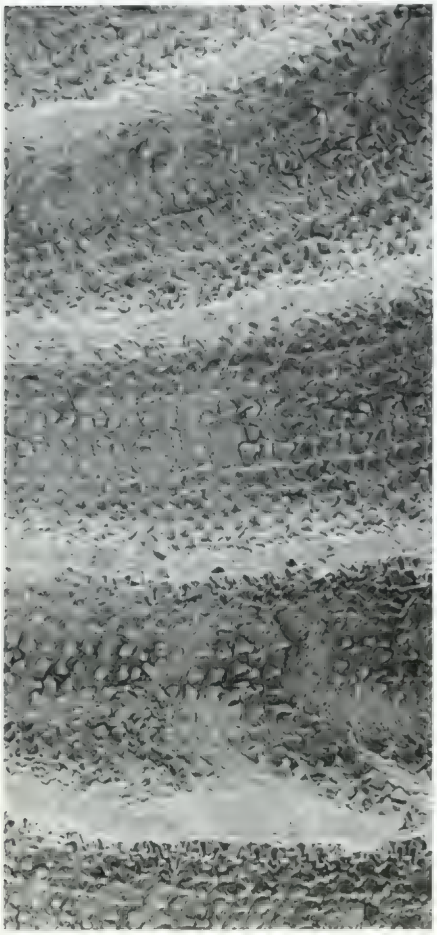
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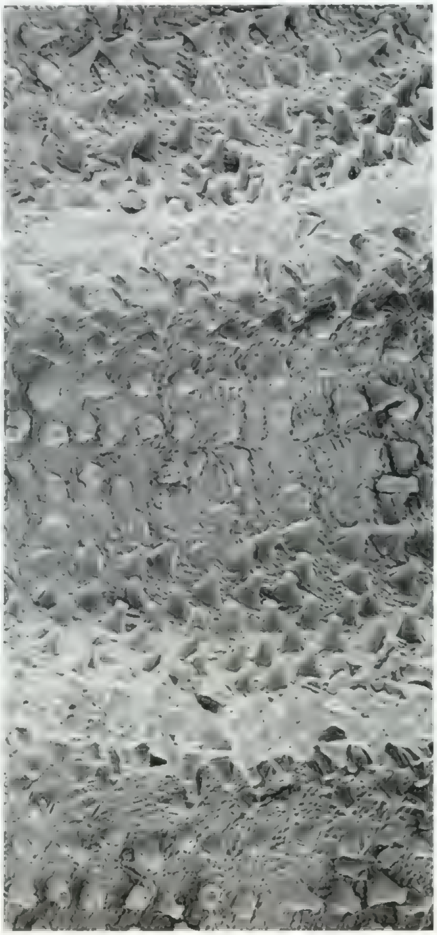
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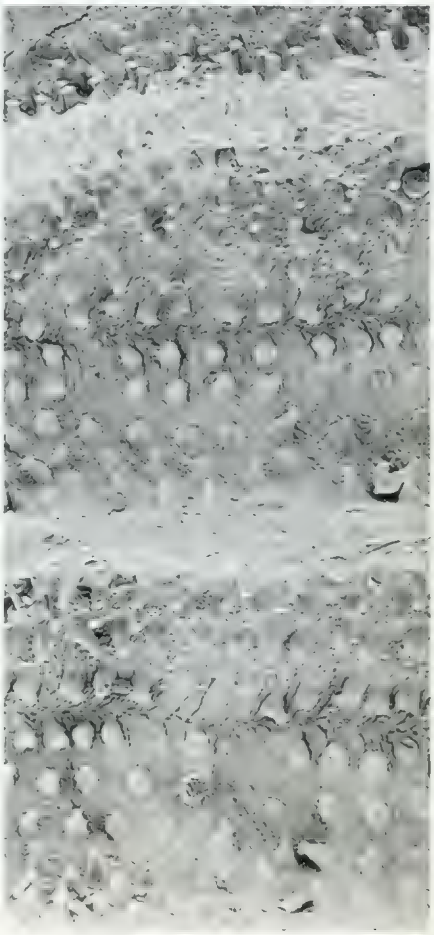
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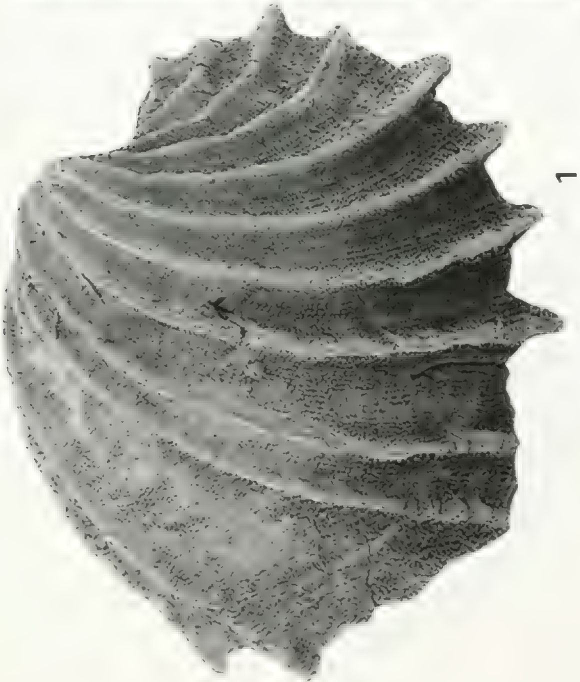
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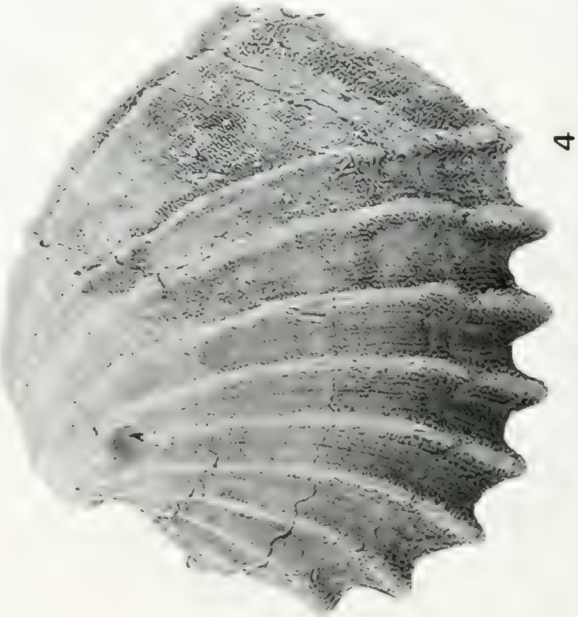
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EXPLANATION OF PLATE 16

Figure Page

1–5. *Trigonulina bowdenensis* (Dall, 1903). 53

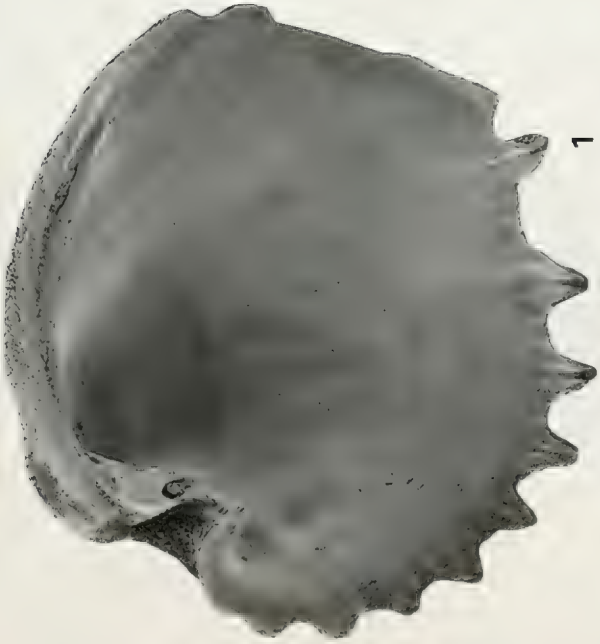
NMB locality 15846: Río Gurabo; Gurabo Formation (late Miocene).

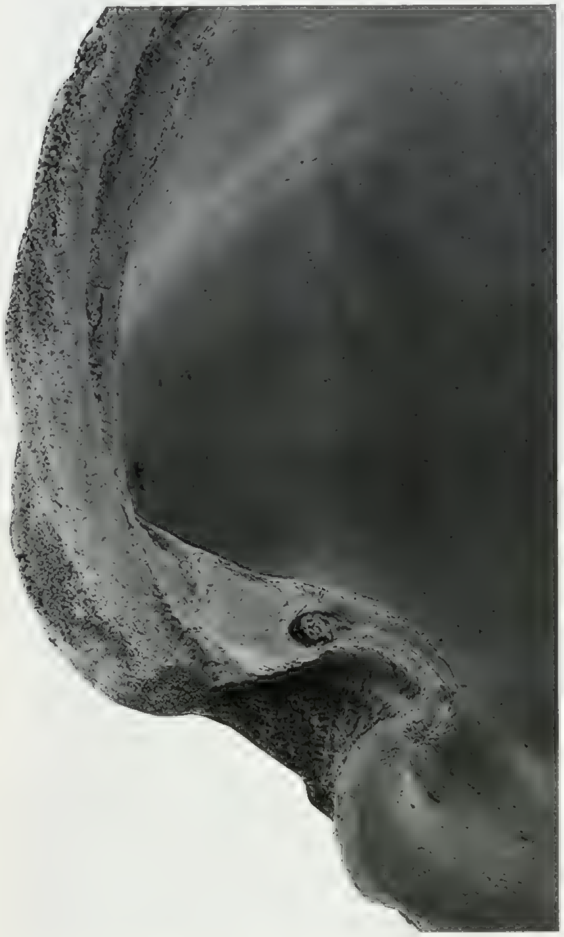
1–3. NMB G 14150. Exterior of right valve. Length 3.8 mm; height 3.2 mm. 2. Enlargement of sculpture, ×75; 3. Further enlargement of sculpture, ×150.

4, 5. NMB G 14152. Exterior of left valve. Length 4.0 mm; height 3.3 mm. 5. Enlargement of sculpture, ×150.

EXPLANATION OF PLATE 17

Figure		Page
1–4.	*Trigonulina bowdenensis* (Dall, 1903)	53
	NMB locality 10635, Bowden, Jamaica, Bowden Formation (early Pliocene)	
	1, 2. NMB G 14154. Interior of right valve. Length 2.8 mm; height 2.5 mm. 2. Enlargement of hinge, ×60.	
	3, 4. NMB G 14156. Interior of left valve. Length 2.1 mm; height 1.8 mm. 4. Enlargement of hinge, ×90.	


1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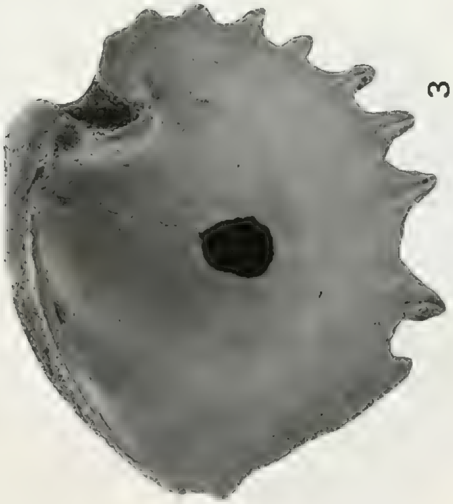
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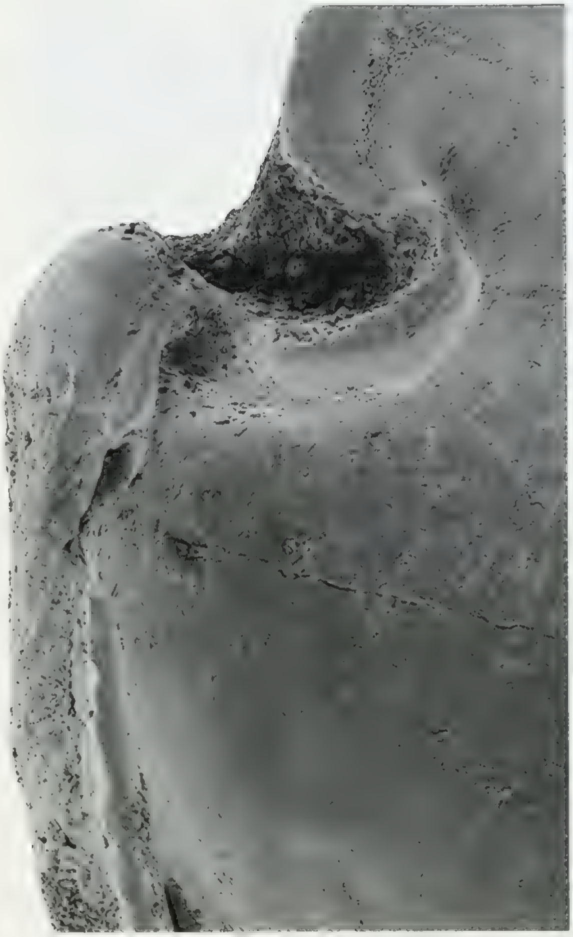
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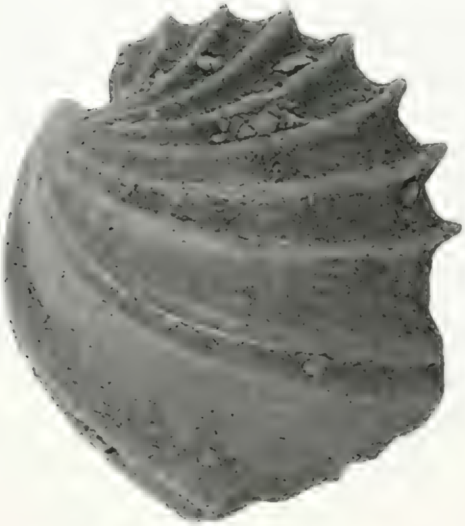

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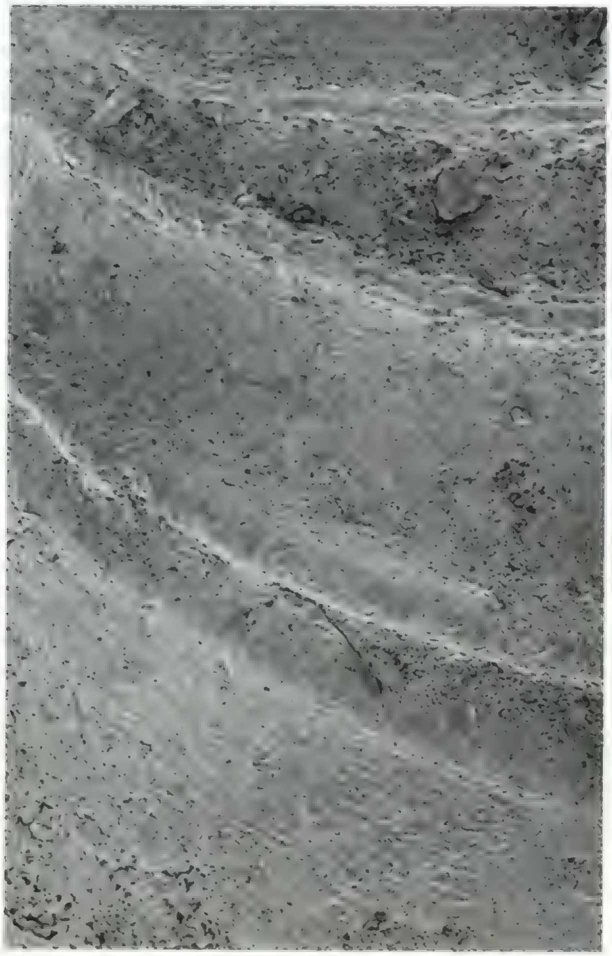

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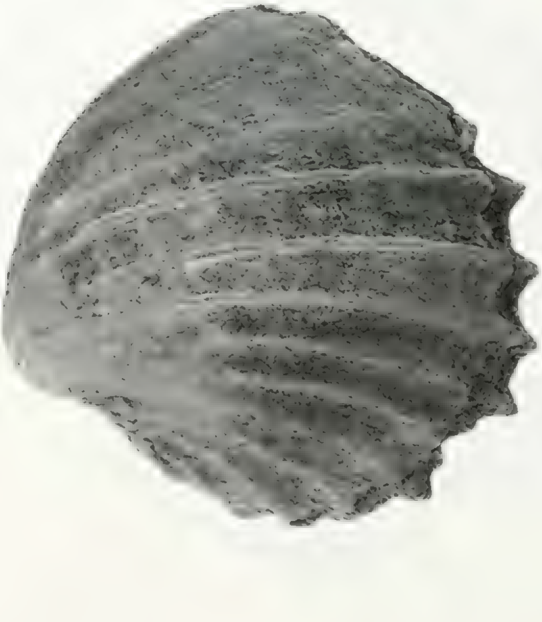

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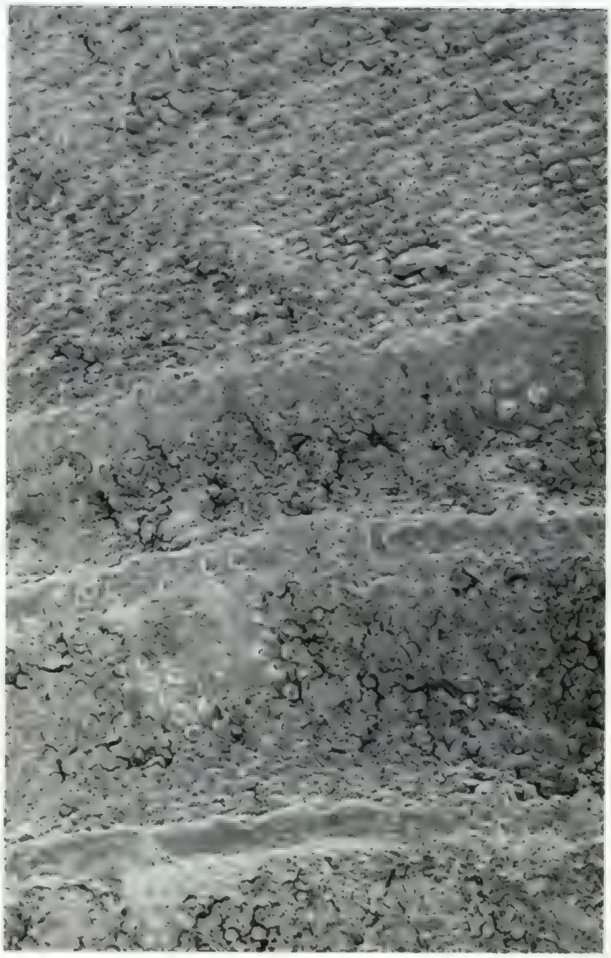

4

EXPLANATION OF PLATE 18

Figure — Page

1–4. *Trigonulina bowdenensis* (Dall, 1903). 53

NMB locality 10635: Bowden, Jamaica; Bowden Formation (early Pliocene).

1, 2. NMB G 14155. Exterior of right valve. Length 2.3 mm; height 1.9 mm. 2. Enlargement of sculpture, ×100.

3, 4. NMB G 14157. Exterior of left valve. Length 2.8 mm; height 2.6 mm. 4. Enlargement of sculpture, ×100.

INDEX

Note: Page numbers are in light face; plate numbers are in **bold face**; page numbers on which principal discussions occur are in *italics*.

- Abbott, 1974 45–48
- Adams, A., 1864 40
- Aguayo, 1943 47
- Ajax Reef 47, 48
- *alternata, Neaera* 40
- Anacapa Island 50
- Arroyo Babosico 36, 43
- Aroyo Bajón 39, 41, 42
- Arroyo Zaloya 36, 43, 46

- Bahía Banderas 50
- Bahía Barithwaite 50
- Bahía de los Angeles 50
- Bahía de los Muertos 50
- Bahía Escodido 50
- Bahía Guatulco 50
- Bahía Herradura 51
- Bahía Juanillo 51
- Baja California 50
- Baja California Sur 50
- Barbados 44, 45
- Bermuda 46, 48
- *bowdenensis, Trigonulina* **15–18**, 35–37, 39–41, 49–*51*
- Bowden Formation 37–43, 46, 49–53
- *Bowdenia* *42*
- Brasil 46, 48

- *caelata, Verticordia* *47*
- California 48, 50, 51
- California Channel Islands 48, 50
- Campeche Bank 45
- Cape Florida 45
- *cardiiformis, Verticordia* 47
- *Cardiomya* A. Adams, 1864 *40*
  - *craspedonia* 39, 41
  - *distira* 36, 37, 39, 40
  - *islahispaniolae* 35–37, 39–41
- *Cardiomya (Bowdenia) distira* **3, 4**, 40–*42*, 43, 46, 51
- *Cardiomya (Cardiomya)* 40
  - *craspedonia* 41
  - *islahispaniolae* **1, 2**, 38–*40*
- Carpenter, 1864 44
- Catalina Island 51
- Cedar Keys 45
- Cercado Formation 40–42, 44, 45, 52, 53
- Costa Rica 51
- *craspedonia, Cardiomya* 39, 41
- *craspedonia, Cardiomya (Cardiomya)* 41
- *Cuspidaria*
  - *gabbi* 40, 41
  - *islahispaniolae* 40
  - *ornatior* 40, 41
- *Cuspidaria (Bowdenia) distira* 42
- *Cuspidaria (Plectodon)*
  - *granulata* 44
  - *scabrata* 44
- Cuspidariidae 35, 39–41

- Dall, 1881 44
- Dall, 1886 40, 44, 45, 47
- Dall, 1889 47
- Dall, 1903 39, 41–45, 51
- Dall and Simpson, 1901 47
- *distira*
  - *Cardiomya* 36, 37, 39, 40
  - *Cardiomya (Bowdenia)* **3, 4**, 40–*42*, 43, 46, 51
  - *Cuspidaria (Bowdenia)* 42
- Durham, 1944 40

- Ecuador 44

- Fast, 1978 39, 40
- *fischeriana*
  - *Haliris* 46
  - *Verticordia* 45
- Florida 37, 44–48
- Fowey Light 47, 48

- Gabb, 1873 40
- *gabbi, Cuspidaria* 40, 41
- Galapagos Islands 44, 51
- Gardner, 1926 44
- Gardner, 1945 40
- *gouldiana, Neaera* 40
- Grant and Gale, 1931 40, 48, 51
- *granulata*
  - *Cuspidaria (Plectodon)* 44
  - *Leiomya (Plectodon)* 44
  - *Neaera* 44
- *granulatus, Plectodon* **2, 5–7**, 36, 37, 40, *44*
- Guanacaste Province 51
- Gulf of California 50, 51
- Gulf of Mexico 45
- Gull Island 50
- Guppy, 1876 40
- Gurabo Formation 41–43, 52, 53

- *Haliris* *45*
  - *fischeriana* 46
  - *jamaicensis* **9, 10**, 36, 37, 39–41, *45*, 46
- Harris, 1919 40
- Hatteras 47
- Hertlein and Grant, 1972 48, 51
- Hinds, 1843 40
- Hopkins Marine Station 50

- Institut Français du Petrole 35
- Isla Cedros 50
- Isla Danzante 50
- *islahispaniolae*
  - *Cardiomya* 35–37, 39–41
  - *Cardiomya (Cardiomya)* **1, 2**, 38–*40*
  - *Cuspidaria* 40
- Isla Smith 50
- Isla Socorro 50
- Islas Revilla Gigedo 50
- Isla Todos Santos 50

- Jalisco 50

Jamaica 37, 39–43, 46, 47, 49, 51–53
jamaicensis
  Haliris **9, 10**, 36, 37, 39–41, *45*, 46
  Verticordia (Haliris) 45
Jung, 1986 35, 36
Jung, 1989 40
Jung, 1994 36
Jung and Petit, 1990 36

Keen, 1971 44, 47, 48, 51
Kellett Channel 50
Knudsen, 1982 44, 45, 47, 48, 51

La Barranca 36, 43
La Paz 50
Leeward Islands 44
Leiomya (Plectodon) granulata 44
Lesser Antilles 44

Mao Formation 43, 46, 52, 53
Massachusetts 46, 48
Maury, 1917 39, 40
Mexico 45, 50
Meyer and Aldrich, 1886 40
Miami 48
Mississippi Delta 45
Monterey Bay 50, 51

Neaera
  alternata 40
  gouldiana *40*
  granulata 44
  ornatissima 40
North Carolina 45

Oaxaca 50
Olsson and Harbison, 1953 44
Orbigny, d', 1842 46, 47
Orbigny, d', 1845? 46
ornata
  Trigonulina **11, 12,** 40, 46, *47*, 48–52
  Verticordia 47, 48
  Verticordia (Trigonulina) 47, 48
  Verticordia (Verticordia) 48
ornatior, Cuspidaria 40, 41
ornatissima, Neaera 40

pacifica, Trigonulina **2, 13, 14**, 35, 40, *48*–52
Pacific Grove 50
Palmer, 1958 44
Peru 51
Pilsbry, 1922 40, 41
Pilsbry and Johnson, 1917 40, 41
Plectodon Carpenter, 1864 44
  granulatus **2, 5–7**, 36, 37, 40, *44*
  scaber 44

Punta Arena de la Ventana 50
Punta Quepos 51
Puntarenas Province 51

Rancho El Tule 50
Rancho Palmilla 50
Renevier, 1855 47
Río Cana 38, 41, 42, 44, 52, 53
Río Cana section 36, 45
Río Gurabo 41–43, 46, 52
Río Gurabo section 36, 43, 46
Río Mao 38–42, 52
Río Mao section 36
Rios, 1985 47
Río Verde 36, 52, 53
Río Yaque de Norte 36, 43
Roca Vagares 51

San Diego 51
Santa Catalina Island 48, 50
Santa Cruz Island 50
Saunders, Jung, and Biju-Duval, 1986
35, 37–39, 42, 43, 45, 46, 52, 53
Saunders, Jung, Geister, and Biju-Duval, 1982 35
scaber, Plectodon 44
scabrata, Cuspidaria (Plectodon) 44
Schenck, 1945 44
Shoal River Formation 37, 44, 45
Sombrero Island 44
Sowerby, 1844 47
Stoliczka, 1871 45
Swiss National Science Foundation 35
Sykes, 1906 47

Trigonulina 35, *46*, 47
  bowdenensis **15–18**, 35–37, 39–41, 49–*51*
  ornata **11, 12**, 40, 46, *47*–52
  pacifica **2, 13, 14**, 35, 40, *48*–52
Turner, 1938 40

Verrill, 1882 47
Verrill, 1884 47
Verticordia 47
  caelata 47
  cardiiformis 47
  fischeriana 45
  ornata d'Orbigny, 1842 47
  ornata d'Orbigny, 1846 47
Verticordia (Haliris) jamaicensis 45
Verticordia (Trigonulina) ornata 47, 48
Verticordia (Verticordia) ornata 48
Verticordiidae 35, 39–41, 45
Vokes, 1939 40

Woodring, 1925 41, 43, 45–47, 51

Yucatan 45

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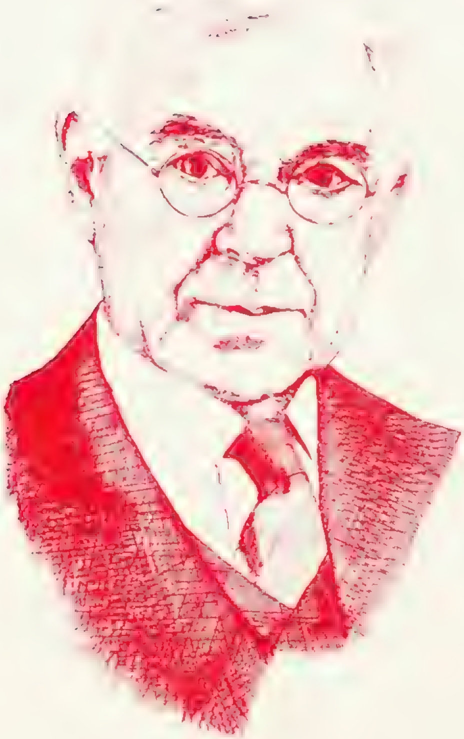

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by

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CONTENTS

- Abstract 5
- Introduction 6
- Acknowledgments 6
- History 7
- Stratigraphy 9
  - Measured Sections 10
  - Locality Descriptions 10
- Collection and Preparation of Specimens 17
- Depositional Environment 17
- Composition of the Fauna 18
- Repository Abbreviations 20
- Systematic Paleontology 20
  - Introduction 20
- Systematics 21
  - Class Bivalvia 21
    - Family Nuculidae 21
    - Family Nuculanidae 22
    - Family Arcidae 25
    - Family Noetidae 27
    - Family Glycymerididae 28
    - Family Mytilidae 28
    - Family Pinnidae 29
    - Family Pteriidae 30
    - Family Propeamussiidae 31
    - Family Plicatulidae 31
    - Family Gryphaeidae 32
    - Family Lucinidae 32
    - Family Chamidae 33
    - Family Carditidae 34
    - Family Mactridae 35
    - Family Solenidae 36
    - Family Tellinidae 36
    - Family Kelliellidae 38
    - Family Pitariidae 39
    - Family Corbulidae 40
    - Family Hiatellidae 41
    - Family Teredinidae 42
    - Family Pholadomyidae 43
    - Family Periplomatidae 43
    - Family Cuspidariidae 44
    - Family Verticordiidae 44
  - Class Scaphopoda 45
    - Family Gadilinidae 45
    - Family Dentalidae 46
    - Family Gadilidae 46
  - Class Gastropoda 47
    - Family Neritidae 47
    - Family Litiopidae 48
    - Family Turritellidae 49
    - Family Littorinidae 50
    - Family Vitrinellidae 51
    - Family Skenidae 52
    - Family Strombidae 54
    - Family Fossaridae 54
    - Family Vermetidae 55
    - Family Ovulidae 55
    - Family Cypraeidae 56
    - Family Naticidae 57
    - Family Cassidae 60
    - Family Ficidae 62
    - Family Cerithiopsidae 63
    - Family Epitoniidae 64
    - Family Eulimidae 66

Family Muricidae . . . 67
Family Columbellidae . . . 68
Family Columbrariidae . . . 70
Family Cymatiidae . . . 71
Family Nassariidae . . . 71
Family Fasciolariidae . . . 75
Family Melongenidae . . . 80
Family Buccinidae . . . 82
Family Volutidae . . . 85
Family Harpidae . . . 86
Family Olividae . . . 87
Family Cancellaridae . . . 87
Family Mitridae . . . 89
Family Conidae . . . 90
Family Turridae . . . 90
Family Mathildidae . . . 105
Family Architectonicidae . . . 108
Family Terebridae . . . 112
Family Cylichnidae . . . 113
Family Retusidae . . . 113
Family Ringiculidae . . . 115
Family Philinidae . . . 115
Family Acteonidae . . . 116
Family Pyramidellidae . . . 117
Family Umbraculidae . . . 121
Class Cephalopoda . . . 121
Family Sepiidae . . . 121
Family Hercoglossidae . . . 122
Family Aturiidae . . . 122
References Cited . . . 123

LIST OF ILLUSTRATIONS

Text-figure Page
1. Eocene stratigraphic units in Texas . . . 7
2. Paleogene correlation chart of Eocene and some Oligocene standard ages and formations in the Gulf Coast, California and western Europe . . . 11
3. Explanation to profile of composite section . . . 12
4. Profile of two localities in Joe Taylor Branch, Milam County, Texas. Source of many species described in the text . . . 13
5. Maps showing the extent of the Reklaw Formation in Texas and fossil locations discussed in the text . . . 16
6. Charts showing the abundance and diversity of the fauna distributed between seven habitats . . . 19

TABLES

Table Page
1. Table showing relative abundance of species found in Ridge Creek and Joe Taylor Branch and their inferred environment . . . foldout inside back cover

THE MOLLUSCAN MACROFAUNA OF THE REKLAW FORMATION, MARQUEZ MEMBER (EOCENE: LOWER CLAIBORNIAN), IN TEXAS

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ABSTRACT

An abundant and well-preserved molluscan fauna from the Marquez Shale Member of the Reklaw Formation in East and Central Texas contains more than 188 species of molluscs, of which 123 are referred to new species, 6 to new subspecies, and 38 can be referred to previously described forms. A further 16 can only be generically assigned. Four new genera, and two new subgenera are defined. The majority of specimens came from two localities, Joe Taylor Branch of Two Mile Creek in Milam County, and Ridge Creek in Bastrop County. Two suites of specimens from the Texas Memorial Museum and the Philadelphia Academy of Natural Sciences respectively were also examined, as labels indicated a Reklaw age. Both of these suites were collected in the 1890's, and although possibly collected in the Reklaw formation, it is believed they are more likely to have come from the Queen City or Weches formations; they are also treated in the text. The character of the deposits and the conditions under which the associated fauna of corals, bryozoans, vermes and vertebrate remains is found, suggest a near shore, open marine environment. The fauna is a mixture of lagoonal elements, some with signs of wear, an open sea, near-shore component, and a very well-preserved, size-sorted marine component from deeper water. A few brackish water species and one possible fluviatile species could indicate the proximity of estuarine conditions. Most of the new species and genera were found in several exposures in Joe Taylor Branch of Two Mile Creek. Many of these localities were not previously known to be fossiliferous. The stratigraphy of several sections is described on Joe Taylor Branch. All previously described fossiliferous localities of the Marquez Shale Member of the Reklaw Formation were revisited, and collections made if possible.

The following new genera and subgenera are proposed: Bivalvia: *Tenuimactra*; Gastropoda: *Pseudometula, Trimalaxis, Hastula (Bulbihastula), Surculoma (Volutapex), Eocythara.* The following new species and subspecies are proposed: Scaphopoda: *Dentalium (Antalis) palmerae, Fustiaria (Episiphon) aciculata, Cadulus bisissura;* Bivalvia: *Nucula cochlear, Nuculana (Jupiteria) turgeo, Nuculana (Saccella) demissa, Litorhadia milamensis, Litorhadia undulata, Litorhadia valdefragilis, Barbatia (Acar) salebrosus, Barbatia (Cucullaearca) reklawensis, Bathyarca claibornica, Pachecoa (Pachecoa) concentrica, Gregariella ridgei, Amusium (Propeamusium) zinguli, Plicatula pustula, Hyotissa offemanae, Anodontia (Eophysema) reklawensis, Chama taylorensis, Venericor densata reklawensis, Claibornicardia milamensis, Claibornicardia linguinodifera milamensis, Tenuimactra hodgkinsoni, Eosolen shirleyi, Tellina (Eurytellina?) milamensis, Pitar (Calpitaria) turneri, Caryocorbula marquezensis, Notocorbula marquezensis, Bankia (Lyrodobankia) petalus, Cochlodesma (Cochlodesma) ovalis, Cardiomya? fredsmithi;* Gastropoda: *Littorina (Prosthenodon) eofasciata, Tubiola gracilis, Solariorbis discoides, Solariorbis conicus, Solariorbis? parsnaticoides, Theodoxus domicilium, Mathilda (Echinimathilda?) cribraea, Mathilda (Fimbriatella) iugum, Litiopa texana, Bittium (Bittium) tresquatrum, Bittium (Bittium) ridgei, Glyptozaria americanae, Pseudomalaxis reklawensis, Pseudomalaxis acuta, Architectonica (Stellaxis) reklawensis, Architectonica (Patulaxis?) fimbiaea, Architectonica (Granosolarium) aldrichi caterva, Architectonica (Granosolarium) geminicostata, Trimalaxis ora, Serpulorbis? multiclavus, Amaea (Scalina) macula, Amaea (Foratiscala) texana, Rugatiscala cooperi, Amaurellina plummeri, Natica (Naticarius) brevisulcata, Natica (Carinacca) moffitti, Polinices (Pliconacca) onustus reklawensis, Sinum taylori, Sinum moveum, Postalia americana, Neosimnia scobina, Cypraeorbis bulbus, Phalium (Semicassis) reklawensis, Ficopsis nucleoides, Hexaplex eoa, Mitrella (Clinurella) nuttalli, Mitrella (Clinurella) nuttalli lineata, Metula elongatoides, Pseudometula gradus, Distorsio nucleoides, Colwellia bilineata, Tritiaria nodosa, Antillophos multilineatum, Buccinanops ellipticum reklawensis, Bullia altilis harrisi, Fusinus claibornica, Latrius (Polygona) traceyi, Mazzalina conica, Surculites lapillus, Clavilithes parvetorbis, Clavilithes? acus, Levifusus? serrae, Cornulina minax dockeryi, Sycostoma texana, Michela trabeatoides carinata, Euryochetus punctatum, Ancilla (Olivula) staminea reklawensis, Admetula irregularis, Trigonostoma (Ventrilia) herbae, Trigonostoma (Ventrilia) elegantissima, Trigonostoma (Ventrilia) jonesae, Volvariella milamemsis, Conus (Lithoconus) nocens, Coronia taylori, Hesperiturris nodocarinatus crassus, Hesperiturris? monilis, Hesperiturris? monilis levae, Domingella ridgei, Surculoma imbricata, Pyramimitra (Petrafixa) eocenica, Leptosurcula carinata, Eosurcula moorei reklawensis, Tropisurcula milamensis, Tropisurcula (Eodrillia) planus, Tropisurcula (Eodrillia) grandis, Protosurcula? aurora, Spirotropis claibornica, Eocythara texanum, Eocythara lineata, Varicobela filum, Raphitoma (Microsurcula) georgei reklawensis, Raphitoma (Microsurcula) bastropensis, Raphitoma (Microsurcula) iuventae, Hastula milamensis, Hastula (Bulbihastula) ampulla, Hastula (Bulbihastula) longifera, Mnestia rotunda, Mnestia confusa, Volvulella reklawensis, Retusa (Cylichnina) notata, Semiacteon texanum, Pyramidella (Syrnola) pirum, Pyramidella (Cossmannica) filamentosa, Pyramidella (Cossmannica) tundrae, Pyramidella (Cossmannica) tundrae zigguratum, Odostomia (Doliella?) ova, Turbonilla (Ptycheulimella) meta, Melanella minutissima, Umbraculum tomaculum.* Cephalopoda: *Belosepia pennae.*

Other proposed changes in taxonomic assignments include: *Eodrillia* is made a subgenus of *Tropisurcula. Pyramimitra* is removed from the Mitridae and placed in the Turridae. *Cyclostremiscus axacuus* replaces *Cyclostremiscus exacuus.*

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INTRODUCTION

I was prompted to begin collecting in the Reklaw by visiting stop 11 in a guide book by F. E. Smith (1962), and discovering a handful of well-preserved molluscs. This led to an investigation of the creekside exposures in the shale, from the roadside locality to the nearby Brazos River. The Eocene molluscan fauna of Texas has been known since Ferdinand Roemer's first discovery of fossils at Stone City Bluff on the Brazos River in 1846. Since that time a succession of workers, both professional and amateur, have collected and described the Texas faunas, particularly in the Weches and Cook Mountain formations.

Unlike Alabama, with its fine Sabinian and Claibornian Stage faunas, Texas has supposedly few surface exposures with good marine faunas between the Paleocene Midway faunas, monographed by Gardner (1933), and the Weches faunas of the lower middle Claibornian. A few brief references in the geological literature, however, gave reason to believe that such exposures exist. In 1980, I had the opportunity to investigate the surrounding areas in more detail, and some productive exposures were indeed found. Initial investigation centered on the Reklaw exposures near the Brazos River, and this was later increased to include the Reklaw exposures on and near the Colorado River. A search through the literature and further field work resulted in rediscovery of another locality in Rusk County. This report is the result of 12 years of intensive collecting in the Marquez Shale Member and is the first of a planned series. Later reports will cover the Seguin and other more minor faunas.

The Reklaw Formation consists of two members, the upper Marquez Shale member and the lower Newby Sand member. Both members weather rapidly, probably due to the decomposition of finely disseminated pyrite in the glauconitic sandy layers. Exposures of both members examined proved to be sparingly fossiliferous, usually with only leached imprints of the fauna. A few exceptional exposures in the Marquez Member provided the bulk of the specimens collected. The Marquez Shale Member has a higher clay and glauconite content than the Newby member, and fossils can be obtained after a flood has scoured the creeks, or by excavating. The lower Newby Member is also fossiliferous in east Texas, but is very prone to leaching due to the high sand content of the strata. Surface exposures in the east-central area between the Colorado and Brazos Rivers appear unfossiliferous. In easternmost Texas, Stenzel (1939) notes a fossiliferous layer in the Newby Member composed primarily of a subspecies of *Venericor densata* Gardner and Bowles, 1939; this area is not treated in this report. Some additional Reklaw molluscs were also found in the collections of the United States National Museum, the Academy of Natural Sciences of Philadelphia, and the Texas Memorial Museum. Few references have previously been made to the Reklaw faunas, and then often in such terms as "dwarfed faunas", and "small gastropods similar to the Stone City species". In contrast, my work in the Reklaw indicates that it contains a diverse and unusually well preserved macrofauna of molluscs, corals, bryozoans and fish remains.

This study is primarily a faunal description, and as such fills a chronological gap in the molluscan fossil record of the southern and eastern United States. The purpose is to provide a reference for the Reklaw molluscan faunas, and to stimulate further investigation of this neglected formation. All molluscan species are treated with the exception of the pteropods that were described in Hodgkinson *et al.* (1992). The limitations of time and residence have hampered the study somewhat, and it is likely that other fossiliferous localities in the Reklaw remain to be discovered. The material obtained, including many unique specimens, indicates the fauna is far more diverse than previously suspected, particularly as the present investigation only deals with a few exposures clustered around two areas; one centered on Joe Taylor Branch Creek in Milam County, Texas and the second around Ridge Creek in Bastrop County, Texas. The specimens obtained are the result of at least 100 collecting trips in the period 1980 to 1992. In addition to surface collecting, bulk samples of 20 kg. or more were normally collected on every trip from the small lenses of shell material that occur relatively frequently. The majority of the taxa, as might be expected, can be assigned with some confidence to an intermediate evolutionary position between similar Sabinian and Middle Claibornian forms.

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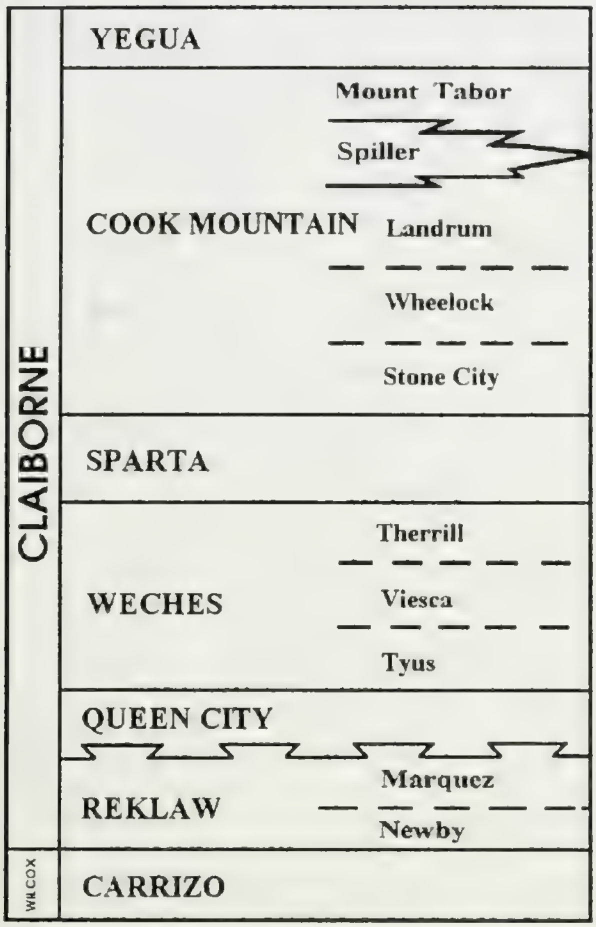


Text-figure 1.—Eocene stratigraphic units in Texas (from Stenzel *et al.*, 1957; Sams and Gaskill, 1990; and Yancey, pers. comm.).

E. Yancey for their thorough review of the draft; their many comments and suggestions have greatly improved the manuscript. In addition the extensive collections and library of the Natural History Museum, London were kindly placed at the author's disposal while in that country by C. P. Nuttall and J. Cooper. The Bayerische Staatsbibliothek in Munich, Germany furnished many rare books not found elsewhere. In the U.S.A., C. Jones and E. Benamy made the collections at the Academy of Natural Sciences in Philadelphia available for study, and P. Hoover placed the Paleontological Research Institution's collections at the author's disposal during several visits there. D. Steere supplied several obscure references at the Smithsonian Institution Libraries. The author is particularly grateful to C. P. Nuttall and C. Jones for their expertise and advice during the early part of this study as difficulties arose. During the long life of this study I have benefited from the suggestions and help of many others, and to all of them I am very grateful. The study might have taken considerably longer without their help. My wife Shirley spent many tedious hours checking many versions of the manuscript and for her patience and endurance I am very grateful.

HISTORY

The Reklaw Formation was regarded as being of Claibornian age as early as 1889 when Penrose (1889, pp. 29–30) described the Colorado River sections from Austin to Smithville. The first fossiliferous exposure downstream from the Travis County line is Bombshell Bluff, an exposure of Reklaw strata which was described as: "consists of thin interstratified layers of glauconitic marl, black clay, and dark siliceous sand with glauconitic specks, . . .". Four miles below this first exposure is "Devil's Eye" where Penrose remarks on "similar ledges of the same strata". The "Devil's Eye" locality does not appear to exist now, and it is believed from the faunal content that this locality should now be referred to the Queen City Formation, although uppermost Reklaw is possible. This fauna shows a greater similarity to the Weches fauna than any of the personally collected Reklaw material. The first determination of some fossils from this locality was made by Heilprin (1891); these were sent to him by Penrose from exposures on Devil's Eye, these were identified as:

Conus sauridens (Conrad, 1833b)
Pleurotoma Tuomeyi Aldrich, 1886
Pleurotoma nodocarinata Gabb, 1860d
Distorsio (Personella) septemdentata (Gabb, 1860d)
Astarte tellinoides Conrad, 1833c
Nucula magnifica Conrad, 1833a
Mitra? sp
Volulithes petrosus? Conrad, 1833a?
Xenophora confusa Deshayes, 1832a
Cytherea Nuttalliopsis Heilprin, 1881
Cardita tetrica Conrad in Wailes, 1854
?Limopsis corbuloides Conrad, 1833b

The other species previously described as occurring in the Reklaw Formation are:

Ancillaria staminea Conrad, 1832b
Orthoyoldia psammotaea vivianensis (Harris, 1919)
Venericardia (Venericor) claiboplata Gardner and Bowles, 1939
Cancellaria sp. *
Latirus aff. L. moorei (Gabb, 1860) *
Murex sp. *
Natica sp. *

Pleurotoma cf. P. texanopsis Harris, 1895a*
Pleurotoma carlottae Harris, 1899 *

Sigaretopsis sp. *

Turritella n.sp. *
Turris cf. T. moorei Gabb, 1860 *
Corals 3 spp. *
Lirodiscus smithvillensis (Harris, 1895a)
Athleta petrosa smithi Fisher and Rodda, 1964
Echinochilus texanum (Harris, 1895a)

Turritella turneri Plummer, 1933
Volutocorbis stenzeli Plummer, 1933
Volvaria gabbiana (Harris, 1895a)
Xenophora confusa (Deshayes) Heilprin, 1891
Terebellum sp. (Harris, 1890)

Katherinella? trigoniata bastropensis (Harris, 1919)
Venericardia cf. V. densata Conrad, 1845*
Glycymeris sp. *
Angulithes elliotti (Stenzel, 1940)
Aturia turneri Stenzel, 1940

The species marked with an asterix were identified by F. E. Turner, and come from the "old Copper prospect", Alsobrook land, Pullen Survey, 4 1/2 miles NE of Harwood, Caldwell County, Texas, and were deposited in the Bureau of Economic Geology in Austin. The lists were compiled from information in Palmer and Brann (1965), Sellars *et al.* (1932), and Heilprin (1891). An attempt was made to locate Penrose's specimens in the Academy of Natural Sciences in Philadelphia, and also to locate the species identified by Turner in the Bureau of Economic Geology collections, now transferred to the Texas Memorial Museum, but no positive identifications could be made. Whether all of the above species even came from the Reklaw is questionable. Several specimens now in the Texas Memorial Museum, that are identified as coming from the Reklaw Formation, and not personally found in the present study, were critically examined. These are believed to be lowermost Weches Formation or Queen City Formation in age. Samples of matrix from within the aperture of two gastropods were found to contain foraminifera known to occur in the Weches. Whether the foraminifera also occur in the Reklaw is not known. The distance from the uppermost Reklaw locality to the lowermost Weches on the Colorado river is only 2.4 km (=1.5 miles), and at the turn of the century, the two formations were united within the Timber Belt or Sabine River beds (Fisher, 1961), which might explain the mixing within the collections.

Other species whose range includes the Reklaw, but have not yet been recognized in the formation are:

Bonellitia tortiplica? (Conrad, 1865a)
Bullia altilis subglobosa (Conrad, 1832b)
Euspira leana (Palmer, 1937)
Galeodea dubia (Aldrich, 1885)

Species previously recognized in the Reklaw, or described from another formation and whose stratigraphic range now includes the Reklaw, are as follows:

Orthoyoldia psammotaea vivianensis (Harris, 1919)
Tellina (Arcopagia) trumani, Harris, 1897b

Mathilda cf. retisculpta aldrichi Palmer, 1937
Bullia altilis harrisi Palmer, 1928
Cornulina cf. armigera (Conrad, 1833a)
Pleurofusia? huppertzi (Harris, 1895a)

Microdrillia rostratula Casey, 1903
Falsifusus ottonis (Aldrich,1886)
Ringicula trapaquara Harris, 1895a
Pyramidella (Cossmannica) perexilis (Conrad, 1865a)
Limacina cf. taylori (Curry, 1965)

Limacina augustana (Gardner, 1951)
Pseudoliva cf. santander Gardner, 1945
Athleta petrosa smithi Fisher and Rodda, 1964
Volutocorbis stenzeli Plummer, 1933

Stenzel (1953) reported a marine faunule from the Newby Member of the Reklaw in Cherokee County, which contained fish remains, molluscs, corals, bryozoa, and a sponge, without specifically identifying the fossils. The small pteropod mollusc, *Limacina stenzeli* Garvie *in* Hodgkinson *et al.,* 1992, mentioned and figured by Stenzel (1953, p. 82, fig. 42), and found by Stenzel in Cherokee County, is restricted to the Marquez Member. It occurs abundantly in all fossiliferous Reklaw sections examined in this report.

Apart from the molluscs I have also collected the following fauna from the Marquez Member:

Corals:
  Turbinola sp.
  Endopachys sp.
  Paracyathus 2 spp.
  Madracis ? sp.
Bryozoans:
  Lunulites 2 spp.
  Encrusting Bryozoan spp.
Annelids:
  Surpula sp.
Arthropoda:
  Carapace fragment of a crab, genus indet.
  Crab claw, genus indet.
Fish remains:
  Numerous spp. of shark and fish teeth
  Fish vertebrae and bones
Whale bones

Since the time of Penrose, very little has been written on the paleontology of the Reklaw. Plummer (1933) gives a short list of five species from the Colorado River valley, and a second list of 22 species from the dump at the side of the "old Copper prospect", *cf.* locality 1. Some plant species are also listed from south Texas. Stephenson (1942, 1944) described ostracoda from the Reklaw in Ridge Creek, Bastrop County (*cf.* localities 2–6). Foraminifera are described by Bannahan (1950), Hussey (1951), and Davis (1961). Stenzel (1950, 1953), provided extensive geologic reports on areas with Reklaw deposits, centered in the Tyler Basin of East Texas. Professor F. E. Smith (oral. commun.) said the late Dr. F. E. Turner of Texas A&M University worked on the paleontology of the Reklaw. Hodgkinson *et al.* (1992) described many Reklaw pteropods in their monograph of the Eocene pteropods of the Gulf and Atlantic coasts. A site with abundant marine macrofossils occurs at a borrow pit exposing the Newby Sand Member in Rusk County, East Texas (*cf.*, locality 25).

STRATIGRAPHY

The Reklaw Formation was first recognized as a distinct unit by Wendlandt and Knebel (1929, pp. 1352–1355), and was described as "a basal layer, 20–40′ thick, of brown to dark blue, micaceous sandy clay; a middle layer, 4–15′ thick, of rather pure clayey glauconite containing plentiful fossils in the middle; and an upper layer of up to 100′ of brown clay with streaks of sand, green-sand, clay and clay-ironstone concretions". The type locality was given as the railroad cut in northeastern Nacogdoches County, 3.2 km (=2 miles) northeast of the village of Reklaw in Cherokee County. Stenzel (1939), in his work in Cherokee County, concluded that the lower 6–12 m (=20–40 feet) of the section graded laterally into, and interfingered with the Carrizo Formation. The middle 1.2–4.6 m (=4–15 feet) was named the Newby Sand Member and the upper 30 m (=100 feet) the Marquez Shale Member. Sams and Gaskell (1990), and Sams (1991) have examined the sequence stratigraphy of the Reklaw, showing the marine transgression occurred in repetitive stages of relative sea level rise. They also identify deepening marine sediments, culminating in a condensed section of 3–4.6 m (=10–15 feet), that has a maximum diversity and abundance of foraminifera.

In south Texas, Trowbridge (1923) named certain clay strata south of Carrizo Springs the "Bigford" and supposed them to be part of the Wilcox Group; near Carrizo Springs the Bigford apparently grades into the Carrizo. Gardner (1932), raised the Bigford to formation rank, separating it from the Carrizo. In recent years the term Bigford has fallen into disuse being assumed equivalent with the Reklaw. Stephenson (1953), in field work in East Texas, notes a ferruginous conglomerate, previously thought to be terrace deposits, giving evidence for it being possibly the basal bed of the Reklaw and overlying a possible eastern extension of the Bigford. During the field work fossils were found in the conglomeratic bed, and the underlying stratum, but were not well enough preserved to fix the stratigraphic age as Reklaw. Stephenson did note that the fossils appeared to be distinct, but had a general similarity to forms and faunas of the lower Claiborne Group. I examined the ferruginous conglomerate samples deposited at the Smithsonian Institution. A previous investigator had made rubber casts from the fossil molds. I examined these casts and several species were found to be specifically identical with species described later in this report from the Reklaw. Amongst the casts, were two diagnostic species, *Tritiaria nodosa* n.sp. and *Colwellia bilineata* n.sp., both so far restricted to the Marquez Shale Member of the Reklaw formation. No such wide-ranging conglomerate bed is mentioned in Sams and Gaskell (1990), although in Gonzales County Sams (1991, p. 153) described a similar pebble-moulded, hematite-cemented, sandstone bed in the Guadalupe River section.

Elisor (1929) traced the Reklaw into Louisiana and placed it below the Sparta Sand and above the Cane River Formation, while Hussey (1949), and Guevara and Garcia (1972), correlated the Reklaw with the lowest part of the Cane River Formation in Louisiana. Further east in Mississippi and Alabama the Tallahatta Formation is generally regarded as the equivalent of the Reklaw and Queen City formations. Gardner (1957, pp. 573–578) discussed the lithology and paleoecology of the Tallahatta formation exposed in Little Stave Creek, Clarke County, Alabama. In the region of the Rio Grande, the Reklaw (there regarded as equivalent with the Bigford) is approximately 213 m (=700 feet) thick, in Bastrop County—73 m (=240 feet) (Lyth, 1949), in Milam County—59 m (=195 feet) (Dunlap, 1955), in Robertson County—41 m (=133 feet) (Davis, 1961), in Leon County—30 m (=100 feet) (Stenzel, 1953), and in northern Cherokee County—27 m (=90 feet) (Stenzel, 1953). Within Milam County, Dunlap (1955) divided the Marquez Shale Member into three lithologic units; a lower crossbedded stratum of mainly carbonaceous shales containing sands and irregular concretionary layers; a middle evenly-bedded stratum of dark-green glauconitic fossiliferous shale; and an upper crossbedded stratum of shales with limonitic partings, iron-stone concretionary layers, and sand lenses.

A tentative correlation of the Reklaw with west coast faunas may be made via the foraminifera and calcareous nannoplankton zones. Hodgkinson *et al.* (1992, p. 9) noted that the Reklaw falls within the nannoplankton zone 13 as used by Dockery (1986). Of those foraminifera species which Davis (1961) found restricted to the Reklaw, five were found by Weaver and Molander (1964) in the Eocene Cozy Dell or lower Sacate-Gaviota Formations of Santa Barbara County, California. These species are:

Anaomalina costiana Weinzierl and Applin
Cibicides sassei Cole
Haplofragmatoides cf. mauricensis Howe and Ellis
Robulus alato-limbatus (Guembel)
Trochammina claibornensis Howe

The only one of these not listed as rare is *T. claibornensis,* and it is restricted to the lower part of the Cozy Dell Formation. Weaver and Molander (1964) regard these two formations as Late Eocene (Narizian) in age, and approximately contemporaneous with the Domengine-Tejon Formations. Squires (1987, p. 8) cites literature which places calcareous nannoplankton zone 13, as being contemporaneous with the upper Carpay and lower Domengine molluscan stages.

The occurrence of the planktonic pteropod, *Limacina taylori* (Curry, 1965) in Taylor Branch (Hodgkinson *et al.,* 1992, p. 20) also establishes the Marquez Shale member to be contemporaneous with the lower part of the London Clay formation in England.

Other exposures of the Reklaw at Wolf Den Branch of Mud Creek, south of Franklin, Robertson County, and on the upper reaches of Threemile Creek, (*cf.* Smith, 1962, p. 9, stop 11 of the field trip guide), were investigated and with the exception of a few imprints of *Calorhadia* sp. in the ironstone beds of the creek near Franklin, and in the clays of Threemile Creek, were found to be nonfossiliferous. In the northeastern parts of Cherokee County, where Stenzel (1953) has described fossiliferous exposures from both the Newby and Marquez members, all the fossils localities in the Marquez Shale are leached, so that only imprints remain. The exposure in the Newby member mentioned by Stenzel (1953, p. 75) is now a very poor collecting site. To the west of Milam County, fossiliferous exposures are known from the Colorado River at several points, the first to be collected was known as Devil's Eye locality, 12.8 km (=8 miles) SE of Bastrop, Bastrop County, Texas. This locality produced the fossils described by Heilprin (1891), now in the Academy of Natural Sciences in Philadelphia.

The majority of specimens for this study came from Joe Taylor Branch (localities 12–22), and Ridge Creek (localities 2–7). Most of the exposures at these sites are sparingly but uniformly fossiliferous. Specimens tend to be very poorly preserved in the downstream part of the creek, owing to the permanently weathered condition of those exposures. Fossiliferous sediments in the Milam and Robertson County areas seem to be a local feature restricted to Joe Taylor Branch, the Bluff on the Brazos River just upstream of the mouth of the creek, and a small unnamed creek 1 km (=5/8 mile) upstream. In 1986 beavers invaded Joe Taylor Branch, and their resultant dams made collecting all but impossible, so Ridge Creek in Bastrop County was investigated in more detail. The beavers are no longer in evidence on Joe Taylor Branch, but it has never recovered its former productivity. Lyth (1949, p. 28, 35), noted well-preserved macrofossils from two exposures on Ridge Creek. Localities 3 and 4 were the site of very fossiliferous silty/sandy lenses and have produced the bulk of the specimens from this creek.

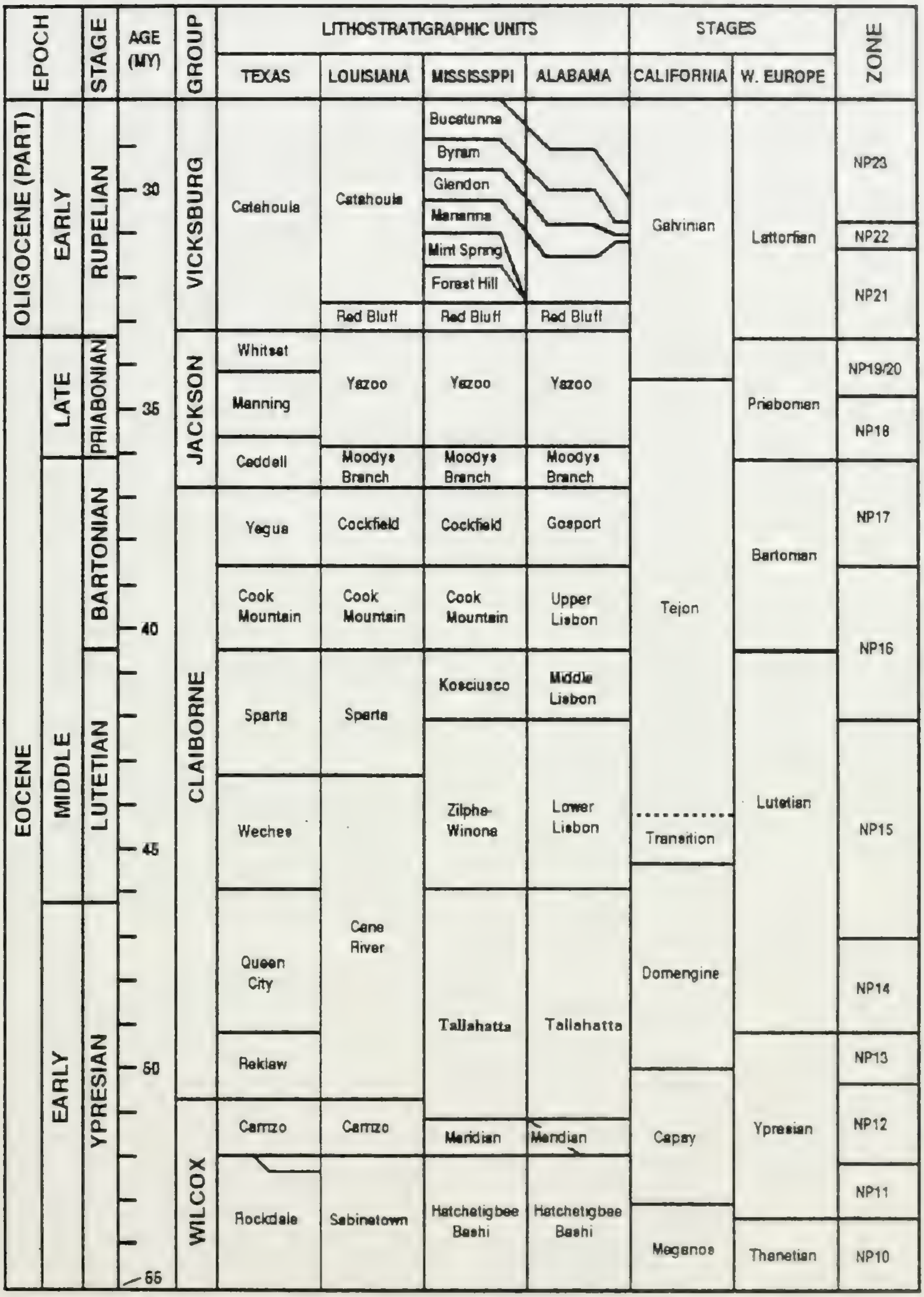
Most of the specimens were found concentrated in two depositional modes. The first mode is where specimens are found in thin, lenticular sandy lenses which appear to be storm deposits. The second mode where collecting is always good is a partially indurated glauconitic bed that marks the base of the unit B in Joe Taylor Branch. It is believed this thin glauconitic zone, easily recognized in the field, is the same zone that outcrops at the Colorado River banks at locality 7, and is also the same as bed 4c of Lyth (1949), in Ridge Creek. Bed 4c is about 3.4 m (=10 feet) above the Newby Marquez contact. It is not known if the Devil's Eye specimens examined in both the Academy of Natural Sciences in Philadelphia and in the Texas Memorial Museum derive from that same layer. Dumble (1892) described the strata at the Devil's Eye locality as follows: "The fossil-bearing bed is six to twelve inches thick, is semi-indurated, and composed almost entirely of glauconite and shells.", he also noted the same shell bed at Alum Bluff, at the mouth of Alum Creek, about 4.8 km (=3 miles) upstream of Smithville. None of the exposures examined for this report would appear to be as fossiliferous as those described by Dumble.

Measured Sections

Where applicable, the techniques described in Swanson (1981) were used as the basis for sample descriptions. As sections for Joe Taylor Branch have not been previously published, two typical ones are outlined in Text-figure 4, and explanations on the opposite page. Unit B containing the clay-ironstone layers can be readily followed from locality 15 to the mouth of the creek at locality 23, and can serve as a reference point for the sections. Lyth (1949), Sams and Gaskell (1990), and Sams (1991), may be consulted for a description of the Ridge Creek sections.

Locality Descriptions

Map references are in UTM metric grid notation on the relevant USGS topographic map.

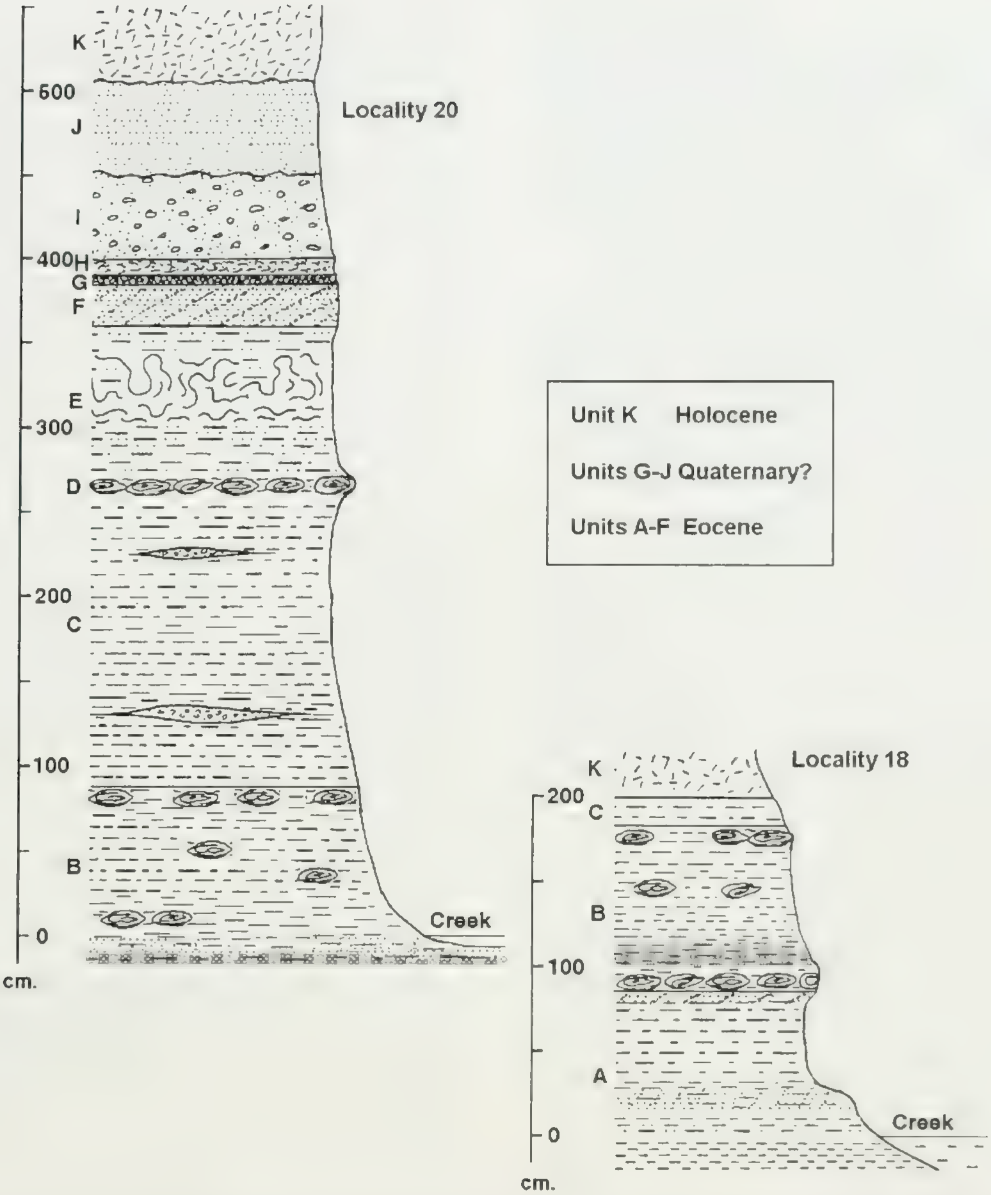

EPOCH
STAGE
AGE (MY)
GROUP
LITHOSTRATIGRAPHIC UNITS
TEXAS
LOUISIANA
MISSISSPPI
ALABAMA
STAGES
CALIFORNIA
W. EUROPE
ZONE
OLIGOCENE (PART)
EOCENE
EARLY
LATE
MIDDLE
EARLY
RUPELIAN
PRIABONIAN
BARTONIAN
LUTETIAN
YPRESIAN
30
35
40
45
50
55
VICKSBURG
JACKSON
CLAIBORNE
WILCOX
Catahoula
Catahoula
Bucatunna
Byram
Glendon
Marianna
Mint Spring
Forest Hill
Red Bluff
Red Bluff
Red Bluff
Whitset
Manning
Caddell
Yazoo
Yazoo
Yazoo
Moodys Branch
Moodys Branch
Moodys Branch
Yegua
Cockfield
Cockfield
Gosport
Cook Mountain
Cook Mountain
Cook Mountain
Upper Lisbon
Sparta
Sparta
Kosciusco
Middle Lisbon
Weches
Zilpha-Winona
Lower Lisbon
Queen City
Cane River
Tallahatta
Tallahatta
Reklaw
Carrizo
Carrizo
Meridian
Meridian
Rockdale
Sabinetown
Hatchetigbee Bashi
Hatchetigbee Bashi
Galvinian
Tejon
Transition
Domengine
Capay
Meganos
Lattorfian
Priabonian
Bartonian
Lutetian
Ypresian
Thanetian
NP23
NP22
NP21
NP19/20
NP18
NP17
NP16
NP15
NP14
NP13
NP12
NP11
NP10

Text-figure 2.—Paleogene correlation chart of Eocene and some Oligocene standard ages and formations in the Gulf Coast, California and western Europe (from Toulmin, 1977, Nelms, 1979, Squires, 1987, Siesser, 1983, and Hardenbol, 1994)

Joe Taylor Branch composite section

Unit	Thickness (cm.)	Description
K		Soil.
J	91	White/light-gray, soft, calcareous sandstone conglomerate.
I	79	Partially cemented sandy conglomerate, brownish yellow in color.
H	8	Friable iron stained sand.
G	2.5	Highly weathered reddish/rust colored limonite deposited in contoured laminations.
F	23	Hard, conchoidally fracturing light-gray sandy siltstone with a few fine laminations and greater amounts of mica than the other units. Glauconite is absent or is only present as isolated grains. Abundantly fossiliferous especially at the base, where a layer of *Notocorbula* sp. occurs with a few larger forms such as *Bullia*, *Ancilla* and *Venericardia*. (Eocene)
E	91	Dark-brown sandy silt, finely laminated at the base (laminations ca.. 1 mm). Upper part micaceous, light yellowish-brown or gray, very sandy, with inclusions of umber-colored clays,and abundant patches of glauconite and areas of greensand. The central portion of this unit contains some highly contorted bedding with isolated patches of laminated silt within the upperpart, and similar isolated patches of greensand and glauconite below. The bed is fairly fossiliferous throughout the upper third with mollusks and corals. Concentrations of fossils are particularly abundant within the areas of greensand and glauconite. Common genera occurring here are *Athleta*, turrid gastropods and the coral *Paracyanthus*; most specimens showing signs of wear. Small subrounded pebbles up to pea size occur scattered throughout the upper third.
D	8-10	Reddish/orange, hard clay/ironstone ledge, or concretionary layer. Contains trace fossils of *Ophiomorpha*.
C	160	Gray to dark brown laminated micaceous mottled sandy silt. Yellow jarosite deposits are common on weathered surfaces. Occasional concentrated glauconite, otherwise isolated pellets of glauconite occur commonly. Some thin sand layers, in places indurated, packed with well-preserved mollusks, corals, bryozoans, fish remains, and occasional rounded pebbles and glauconite. The most common genera are: *Tritiaria, Colwellia, Athleta, Natica, Pyramidella,* turrid species, and *Limacina*.
B	97-112	Dark-gray, micaceous sandy clay, with several layers of light gray to rust-brown, discontinuous clay-ironstone, rarely also indurated sandstone ledges. The base of the bed is characterized by an almost continuous clay-ironstone layer, the upper ledges more lenticular and discontinuous. Above the lowest clay-ironstone layer is a dark-brown to greenish black, discontinuous, glauconitic, sometimes very fossiliferous layer, of maximum thickness 30 cm.; the fossiliferous sections of the glauconitic layer staining bright rust-red when weathering in the presence of moisture. At locality 20 the sandy clay contains several highly fossiliferous sandy lenses. The most common genera are: *Notocorbula, Athleta, Volutocorbis, Barbatia,* turrid species, and corals.
A	> 100	Hard, dark-brown to black silty finely laminated clays. Indurated, sometimes crossbedded lenticular, sand lenses common towards the top of the bed. Fossils occur very sparingly below the top of the bed.

Text-figure 3.—Explanation to profile of composite section on Text-figure 4.



Text-figure 4.—Profile of two localities in Joe Taylor Branch, Milam County, Texas. Source of many species described in the text.

Locality 1. (=TBEG 28-T-9) Dump by old copper mine shaft, E. Pullen survey, east of Sandy Fork Creek, 4.8 miles by road northeast of Harwood, Gonzales County. No trace remains in the fields of the mine or dump, which was apparently dug before 1933, and was an attempt to locate a treasure trove dating from Spanish suzerainty times. This is the type locality of *Turritella turneri* Plummer, 1933, and *Volutocorbis stenzeli* Plummer, 1933.

Localities 2 to 8 are along Ridge Creek (also known locally as Reed's Creek), 0.63 km (=1.0 mile) above the old Missouri, Kansas, and Texas railroad trestle and county road bridge, 10 km (=6.2 miles) west of Smithville, 1.3 km (=0.8) miles east of Upton, Bastrop County, Texas. Marquez member of the Reklaw Formation. Localities 2, 3, 4, and 6 were described by Lyth (1949).

Locality 2. (=Lyth, 1949, locality 4, map reference: ^{06}68.55E, ^{33}20.17N) Bluff on Ridge Creek, approximately 30.5 m (=100 feet) long exposed on north side of creek about 556 m (=1825 feet), (Lyth, 1949, in error says 825 feet) south of Missouri, Kansas, and Texas railroad trestle and county road bridge across Ridge Creek which is approximately 8.0 km west of Smithville or 1 km east of Upton.

Locality 3. (= Lyth, 1949, locality 5, map reference: ^{06}68.45E, ^{33}20.02N) Bluff on Ridge Creek, approximately 91 m (=300 feet) long exposed on the west side of the creek and about 730 m (=2400 feet) south of Missouri, Kansas, and Texas railroad trestle and county road bridge. The upper portion of the bluff has a very fossiliferous sandy lens, now obscured by slumping.

Locality 4. (= Lyth, 1949, locality 7, map reference: ^{06}68.40E, ^{33}19.92N) Bluff on Ridge Creek, approximately 61 m (=200 feet) long exposed on the west side of the creek and about 888 m (=2915 feet) south of Missouri, Kansas, and Texas railroad trestle and county road bridge. This is the site of the majority of the Ridge Creek specimens collected.

Locality 5. (Map reference: ^{06}68.43E, ^{33}19.67N) Bluff on north side of side creek which joins Ridge Creek about 970 m (=3180 feet) south of Missouri, Kansas, and Texas railroad trestle and county road bridge across Ridge Creek. This exposure had one fossiliferous silty lens which yielded most of the specimens of *Laevibuccinum lineatum* Heilprin, 1881. This was also the site of a large well-preserved, but flattened specimen of *Angulithes elliotti* (Stenzel, 1940), about 30 cm in diameter. This locality was not described by Lyth (1949).

Locality 6. (= TBEG 11-T-7, and Lyth, 1949, locality 6, map reference: ^{06}68.69E, ^{33}19.57N) Bluff on Ridge Creek, approximately 61 m (=200 feet) long exposed on the west side of the creek and about 3700 feet south of Missouri, Kansas, and Texas railroad trestle and county road bridge across Ridge Creek. This is the type locality of *Athleta petrosa smithi* Fisher and Rodda, *Angulithes elliotti* Stenzel, and *Aturia turneri* Stenzel. Only very leached sediments are exposed now.

Locality 7. (Map reference: ^{06}68.60E, ^{33}19.24N) Loose fossiliferous limonitic slabs in bed of Ridge Creek, about 1463 m (= 4800 feet) south of Missouri, Kansas, and Texas railroad trestle and county road bridge, and continuing upstream for about 305 m (=1000 feet) (not described by Lyth (1949). Due to vegetation cover, the level from which these slabs came was not ascertained but it appears to be near the very top of the formation. This exposure is the type locality of *Hexaplex eoa* n. sp., *Bittium ridgei* n. sp.

Locality 8. (=TBEG 11-T-72, Bombshell Bluff, map reference: ^{06}68.17E, ^{33}20.02N) Bluff on Colorado River bank, about 2.4 km (=1.5 miles) west-northwest of Devil's Eye, Bastrop County, Texas. High bluff along right bank of Colorado River, 0.63 km (=1 mile) east of Upton and .64 km (= 0.4 mile) east or downstream from the mouth of Ridge Creek, approximately 10.4 km (=6.5 miles) west of Smithville, Bastrop County, Texas. Marquez Member of Reklaw Formation. The bluff is no longer on the river but is at least 61 m (=200 feet) from the river, just downstream of a wooded island. Part of the bluff is still accessible and is very fossiliferous.

Locality 9. (Map reference: ^{06}68.17E, ^{33}20.02N) Outcropping gray indurated sandstone ledge on Colorado River bank, near water level, extending from just downstream of locality 8 for 61 m (=200 feet), Bastrop County, Texas. Large specimens of *Galeodea (Mambrina) turneri* Gardner, 1939, and *Clavilithes parvetorbis* n. sp. have been found here.

Locality 10. (=TBEG 11-T-35, map reference: ^{06}70.88E, ^{33}23.05N) Davids Bottom, left bank of Colorado River, 0.8 km (=0.5 mile) south of junction of Alum Creek and Little Alum creek, immediately south of dead-end gravel road leading to State Highway 71, Bastrop County, Texas. Marquez Member of the Reklaw Formation. The high river banks are now completely overgrown except for a glauconitic ledge seen only at very low river levels. The ledge extends upstream for some considerable distance.

Locality 11. (=TBEG 11-T-36) Devil's Eye, former island in Colorado river, 12.8 km (=8.0) miles southeast of Bastrop, between TBEG locality 11-T-39 (Kennedy Bluff) and TBEG locality 10. Marquez Member of the Reklaw Formation. Local recollection does not agree with the above description of Devil's Eye but rather with that of Penrose in: Dumble (1890, p. 30) which is described as: ". . . Devil's Eye, an eddy at a low ledge . . .". Nothing remains today of the "island" or low ledge in the river although the ledge can still be seen on the left bank.

Localities 12 to 23 are along banks of Joe Taylor Branch of Two Mile Creek[2]. 0.6 mile upstream from junction with Brazos River. 0.32 km (=0.2 mile) downstream from county road crossing of Two Mile Creek, southeast on county road 1.9 km (=1.2 miles) from U.S. Highway 79, at a point 6.2 km (=3.9 miles) northeast from the center of Gause; the point where the creek crosses the county road is given by U.S.G.S. Gause quadrangle topographic map, reference 96 deg. 39′ 06″ N, 30 deg. 48′ 40″ E. Marquez member of Reklaw formation.

Locality 12. (Map reference: ^{07}24.40E, ^{34}10.76N) Hard black silty clay in bed and banks of Joe Taylor creek, just downstream of county road bridge to 0.9 m (=3 feet) resistant ledge. The banks of the creek have produced irregular echinoids.

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[2] Localities 12 to 23 were measured and described in 1985 and as such due allowance must be made for changes in the intervening time. For example, the author has photographs documenting 12 m of erosion at Joe Taylor Branch creek at Locality 20 in ten years.

Locality 13. (Map reference: ^{07}24.33E, ^{34}10.90N) Banks of creek and small waterfall on small side creek 46 m (=150 feet) upstream of junction with Joe Taylor Branch creek, just below locality 13. This locality has produced fine examples of *Phalium (Semicassis) reklawensis* n. sp.

Locality 14. (Map reference: ^{07}24.52E, ^{34}10.79N) Banks and bed of Joe Taylor Branch creek, from base of 0.91 m (=3 feet) resistant ledge to first bend, a distance of about 244 m (=800 feet). The bed of the creek produced the large *Galeodea (Mambrina) turneri* Gardner, 1939, figured in Plate 14. The right hand creek banks contain stringers with micro-gastropods, one of which contained numerous specimens of *Ringicula cf. trapaquara* Harris, 1895, and *Solariorbis? parsnaticoides* n. sp. At the downstream end of this locality, vertebrae and other bone material of a whale were collected, now deposited at the J. J. Pickle (formerly the Balcones) Research Center, University of Texas at Austin.

Locality 15. (Map reference: ^{07}24.31E, ^{34}10.69N) Hard glauconitic lenticular fossiliferous ledge at right hand bank of Joe Taylor Branch creek at water level. This exposure is the source of many large *Barbatia* spp.

Locality 16. (Map reference: ^{07}24.36E, ^{34}10.67N) Large low ledge at sharp bend of Joe Taylor Branch creek, and below a source of water seepage. Unit B of this locality was the site of some remarkably fossiliferous lenses and was notable for large *Athleta petrosus smithi* Fisher and Rodda, 1964, *Protosurcula? aurora* n. sp., and other large turrid species. The downstream end of this exposure (unit B) is the source of a poorly preserved crab carapace.

Locality 17. (Map reference: ^{07}25.40E, ^{34}10.71N) Left hand bank of Joe Taylor Branch creek, from just upstream of small waterfall over a limonitic ledge to just downstream of intermittent flowing gully, a distance of 15 m (= 50 feet). No large fossils have been found here, but unit A has sandy layers very rich in pteropod species.

Locality 18. (Map reference: ^{07}25.43E, ^{34}10.76N) Banks of Joe Taylor Branch creek about 152 m (=500 feet) long ending at a high cliff on the left bank where the creek enters an open flat area. At the base of a very overgrown bluff are localized and sometimes lenticular sandy zones in the clay, just underneath a sometimes discontinuous limonitic ledge about 1.2 m (=4 feet) above water level. These are locally very fossiliferous and have produced almost all the *Michela trabeatoides carinata* n. subsp. specimens found in the Reklaw.

Locality 19. (Map reference: ^{07}25.57E, ^{34}10.76N) High cliff, about 61 m (=200 feet) long on right hand side of Joe Taylor Branch creek, just downstream of a dry branch. Bed B near the end of the exposure has produced a few larger molluscs. From the description, this would also appear to be locality TBEG 165-T-3 (cf. text-figure 4).

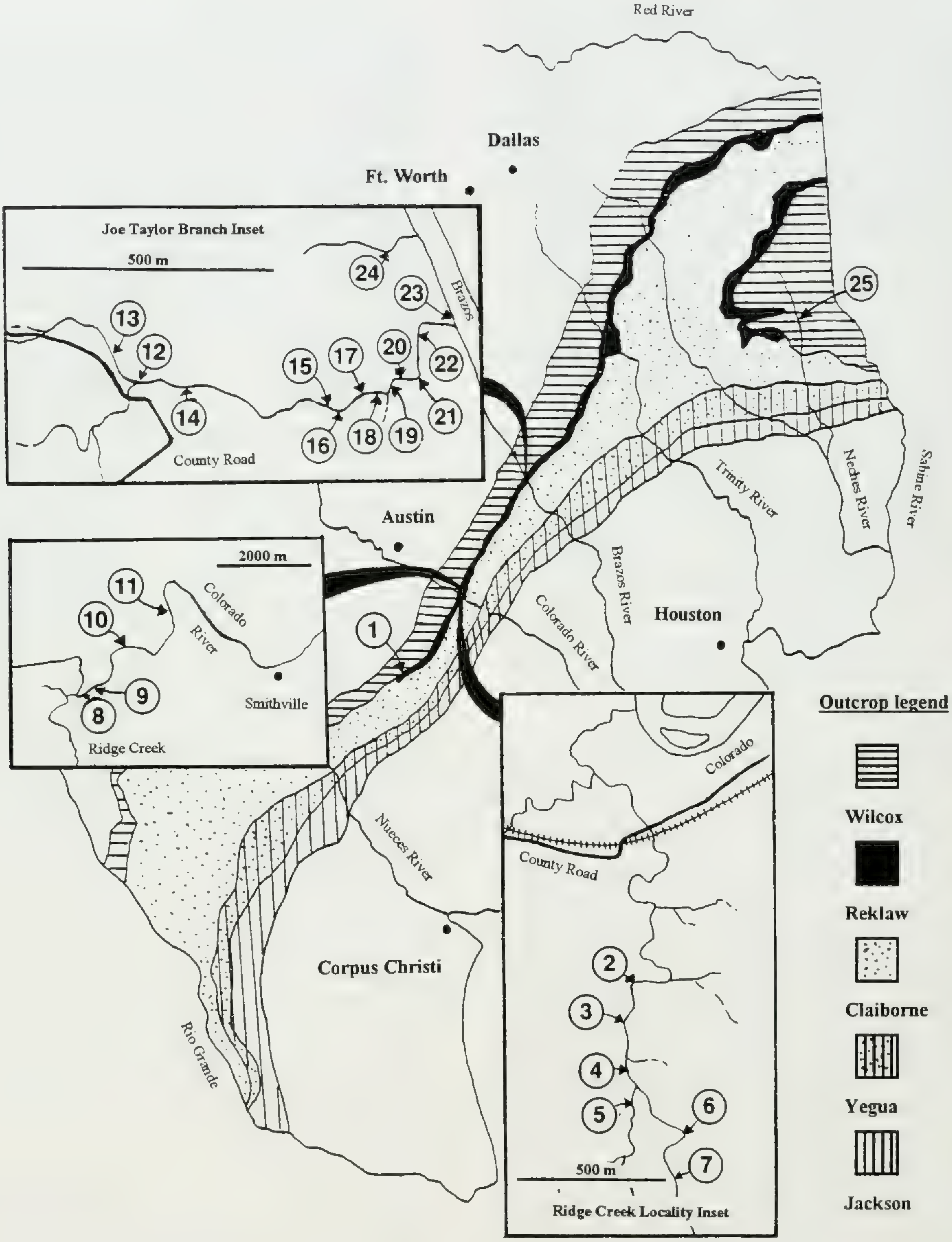
Locality 20. (Map reference: ^{07}25.62E, ^{34}10.86N) High cliff at left side at sharp bend of Joe Taylor Branch creek. The vast majority of fossils found from Joe Taylor Branch creek came from this exposure and most of those from two very fossiliferous lenses, one in bed B just above water level and the other about 6 ft above the base of unit C. Unit F which is first exposed at this locality, is traceable until the end of locality 21, and is also the source of many unique or only rarely found species such as *Buccinanops ellipticum reklawensis* n. subsp., *Strepsidura harrisi* Givens and Garvie, and *Venericor densata reklawensis* n. sp. The base of unit B at the very end of the exposure is the source of numerous specimens of *Pseudoliva cf. santander* Gardner. Unit E is notable for occasional large *Architectonica (Stellaxis) reklawensis* n. sp., and numerous specimens of corals (*Paracyathus* sp.).

Locality 21. (Map reference: ^{07}25.71E, ^{34}10.95N) Long high cliff with initial left hand bend on Joe Taylor Branch creek, ending at small rapids and scree of limonitic boulders. Beds A through K of locality 21 are traceable through this area with a noticeable decrease in sand content and increase in glauconite. The base of unit B has produced the only specimens of *Clavilithes parvetorbis* n. sp. and *Fusinus claibornica* n. sp. found from this creek. Unit B at the downstream end is the site of a large mass of rolled coral and within it the specimens of *Cypraeorbis bulbus* n. sp.

Locality 22. (Map reference: ^{07}25.74E, ^{34}11.09N) Small 1.5 m (= 5 feet) high bluff on right bank of Joe Taylor Branch creek, about 90 m (= 300 feet) downstream from the end of locality 22, ending the Reklaw exposure before its reappearance at the mouth of the creek at locality 24.

Locality 23 (Map reference: ^{07}25.83E, ^{34}11.12N) High bluff on left bank just before the mouth of Joe Taylor Branch creek, and high bluff on right bank of Brazos River. Numerous specimens of a *Paracyathus* coral species. The base of the bluff at low water level has a discontinuous layer of nuculanid bivalves. I have not seen this exposure in an unweathered state.

Locality 24. (Map reference: ^{07}25.57E, ^{34}11.40N)


Red River
Dallas
Ft. Worth
Joe Taylor Branch Inset
500 m
24
23
Brazos
13
12
14
15
17
20
22
21
16
18
19
County Road
25
Trinity River
Neches River
Sabine River
Austin
2000 m
11
Colorado
River
10
9
8
Smithville
Ridge Creek
1
Colorado River
Brazos River
Houston
Nueces River
Corpus Christi
Rio Grande
Colorado
County Road
2
3
4
5
6
7
500 m
Ridge Creek Locality Inset
Outcrop legend
Wilcox
Reklaw
Claiborne
Yegua
Jackson

Text-figure 5.—Maps showing the extent of the Reklaw Formation in Texas (after Collins, 1980, and Sams and Gaskell, 1990) and fossil locations discussed in the text.

Banks of a small unnamed creek entering the Brazos River about 1 km (=5/8 mile) airline distance upstream of the mouth of Joe Taylor Branch creek. The creek side exposures are similar to unit E of locality 20, but even more sparingly fossiliferous.

Locality 25. (=TBEG 200-T-1) Borrow pit on north side of U.S. Highway 84 near east bank of Angelina River, 300 feet west of the river, 4.2 km (=2.6 miles) east of Reklaw, Rusk County, Texas. Newby and Marquez members of the Reklaw Formation. See Stenzel (1953, p. 60, fig. 31) for a detailed section of this locality. The locality is now very weathered but still collectable. The oyster *Hyotissa offemanae* n. sp. is the most common large mollusc present.

COLLECTION AND PREPARATION OF SPECIMENS

Only where sediments were continuously wet were fossils found washed free or observed in situ; on other exposures weathering leaches the fossils from the sediments. With even moderate weathering, the fossiliferous layers become highly indurated, iron-stained and the fossils corroded. Generally, fresh specimens are very fragile, particularly from the sandy lenses in Joe Taylor Creek, the original shell material being partially leached and in many cases secondary calcium carbonate has re-deposited as crystalline growths on the specimens and within the matrix.

As most fossils are fragile, extreme care is required in cleaning and removal of adhering matrix. The process of alternate washing, drying and sieving so useful in disintegrating the shales of the Stone City member and Cook Mountain formations, produces a shell hash of broken, or distintegrated material when applied to the Reklaw fauna. Many of the rarer and unusual specimens were cleaned under 10 or 20 power magnification of a binocular microscope. On many of the highly ornamented forms, adhering grains of sand had to be removed singly using the point of a needle to avoid damaging the specimens. The calcitic crystalline growths, which on gastropods were most commonly cemented to the apex and apertural region and in bivalves to the hinge area, could be removed by careful scraping with a sliver of a razor blade.

A weak solution of cellulose acetate in acetone was frequently used to harden shell surfaces; repairs were made with cellulose acetate cement. As can be seen from a number of figures, in spite of the greatest care, breakage of specimens was common.

DEPOSITIONAL ENVIRONMENT

The sedimentary characteristics at locality 20 are varied: regions of clayey silt alternate with finely laminated sands, glauconite and greensand layers, and the boundaries are often disrupted by contorted bedding, possibly produced by subaqueous slumping. In general the micaceous sediments of unit C are poorly laminated and finegrained. Interspaced within the silts are thin shell-rich layers, containing corals, bryozoans, molluscs, and fish remains. Crossbedding and ripple laminations were not observed. The only mollusc that might indicate fluviatile conditions would be *Theodoxus*, but modern representatives of this genus also live in marine environments.

The condition of the fauna within the shell layers suggests a transported or winnowed assemblage; the bioclasts are mixed and reach a maximum size of about 3 cm. The preservation of the fossils is excellent; even highly ornamented species such as *Chama* and *Volutocorbis* are perfectly preserved and broken or abraded specimens are rare. Moreover, the interior of many gastropods is hollow and some have a brown flakey organic looking substance in the aperture. Within the spire of one specimen the carbonaceous material reached almost to the apex, was not attached to the interior wall and looked very like the dried body of the animal. Several specimens were analyzed at the Electron Microscopy Laboratory at Arizona State University, and Dr. L.A.J. Garvie (pers. comm.) reported the interior substance was almost pure amorphous carbon with other elements below the threshold of detection. If the molluscs were buried with the soft tissues intact, that would indicate a rapid burial. Epifaunal bivalves are almost invariably found disarticulated, in one sample of more than 200, only 5 were found with both valves united.

The sedimentary conditions of unit E suggest a higher energy environment than for the other beds. Fossils and areas of greensand are intermingled, the fossils often broken, and usually extensively abraded. The central part of the bed clearly shows considerable contorted bedding. Bioturbidation was not observed, and in any case is unlikely to account for the large-scale mixing, as the intermixed zones are typically much larger than the fossils. The areas of greensand have the same fauna found in the shell layers, although more sparsely distributed, and generally the specimens are larger. Subangular quarzite pebbles up to 1 cm. are not uncommon in this bed.

Unit F is a fine sandy silt with abundant *Notocorbula* and *Caryocorbula* occurring in the lower part; the lower boundary clearly indicating deposition by currents, as all the scaphopods are aligned parallel to one another. The beds above unit F are eroded away at locality 20, but may be observed both up and downstream of this locality.

Composition of the Fauna

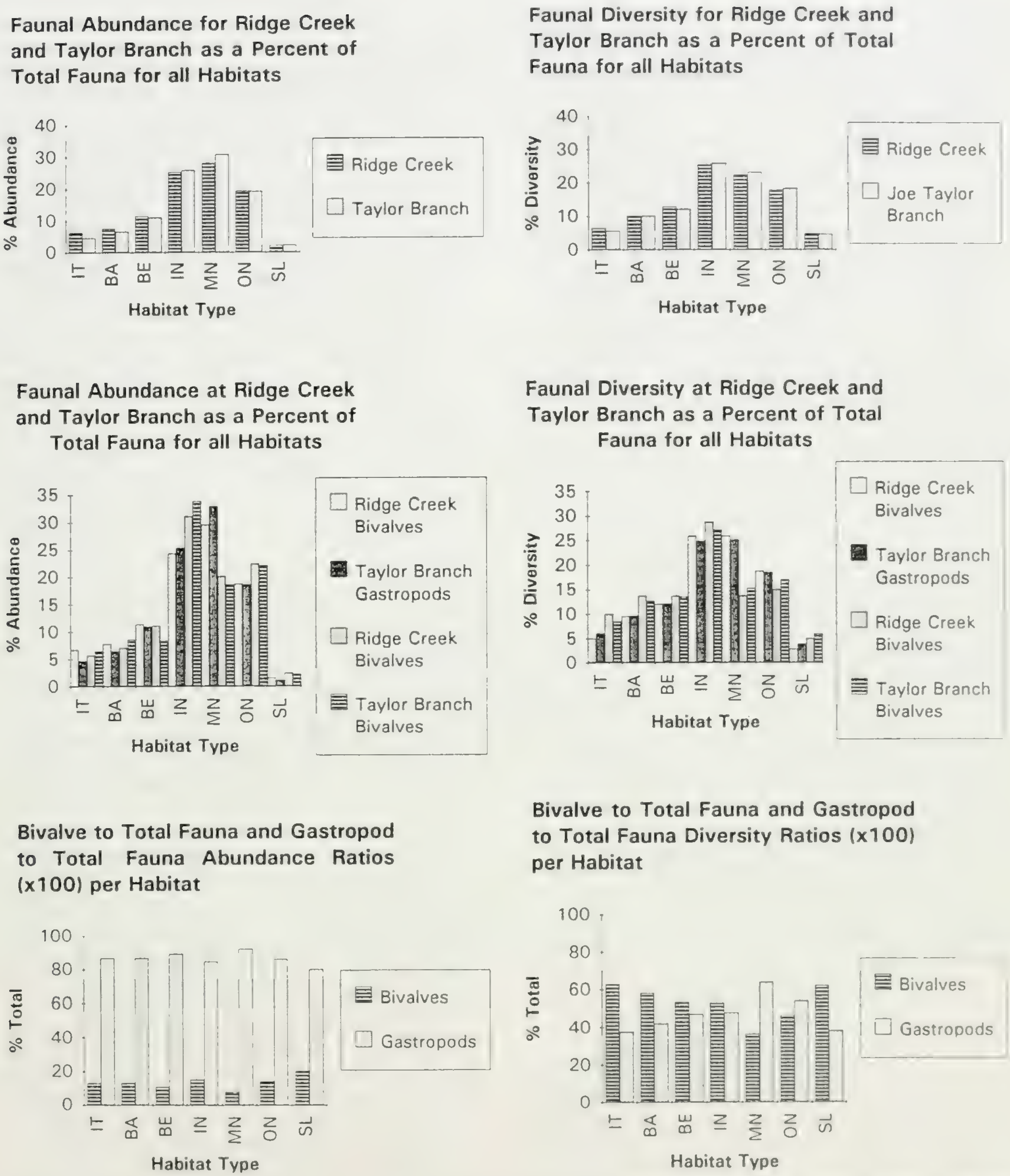
Table 1 (inside back cover) lists the fauna from the two localities where the majority of the collecting was done, **TB**: Joe Taylor Branch (= localities 12–22), and **RC**: Ridge Creek (=localities 2–7). The codes within the latter two columns indicate, a: abundant (100+ specimens), c: common (11–100), u: uncommon (6–10), r: rare (1–5). The habitat is gleaned from various sources, primarily L. Smith (1959, 1962, 1965), Hulings (1955), Natland (1957), and Abbott (1974), and is intended as an indication only. Following Smith the marine environmental continuum is subdivided into the following six habitats:

Inside intertidal (IT):	river channel near mouth; inside beach and marsh, shallow depth; brackish
Bay and pass (BA):	occasional salinity reduction, combined brackish and marine or transitional faunas
Beach (BE):	essentially zero depth to approximately 3 m (=10 feet); normal marine
Inner neritic (IN):	approximately 3 m (=10) feet to approximately 30 m (=100 feet); normal marine
Middle neritic (MN):	approximately 30 m (=100 feet) to approximately 90 m (=300 feet); normal marine
Outer neritic (ON):	approximately 90 m (=300 feet) to approximately 180 m (=600 feet); normal marine
Slope (SL):	shelf edge to continental rise; open sea

The habitat of the many species with no modern relatives was inferred from taxa with similar shell form. Text-figure 5 displays the result of distributing 5125 specimens from Ridge Creek and 3700 specimens from Taylor Branch within the seven habitat types as given in table 1. All complete specimens found during the duration of the study were kept, broken specimens were also kept of the rarer species. The fauna collected is therefore likely to be a good approximation of the original fauna after taphonomic processes. The numerical count of a species was equally distributed between habitat types when more than one habitat was inferred. The computed faunal abundance histogram should be similar in shape to the orginal faunal abundance histogram in the seven habitats, although the computed values would be less than the original values, due to the bias of not collecting all of the original sample. The collection error is unlikely to significantly change the overall shape of the graph, given that the same bias applies to all seven habitats. The diversity count sums the number of different species and subspecies assigned to each habitat; if more than one habitat was inferred a count of one was equally distributed as a fractional value between the habitats. The difference in total diversity and abundance distributions between Ridge Creek and Taylor Branch is very small considering the number of individuals involved, implying a very similar set of environments at the two locations. More than 75% of the fauna is similar to taxa living in the inner neritic to outer neritic habitats with a diversity maximum at the shallow inner neritic. Interestingly, the maximum abundance is in an inferred environment of 30–90 m (=100–300 feet) greater depth than the diversity maximum. Bivalves make up about 12% of the total fauna and gastropods about 88%. In contrast the bivalve and gastropod diversity ratios (counting species and subspecies) are in an inverse relation to each other with a turning point at the middle neritic habitat.

These habitat data support the case for the majority of the fauna being an open marine assemblage, although some current winnowing must have taken place to produce the size-limited specimens in the shell seams. The excellent condition of the shells also implies a low energy depositional environment, although a rapid burial appears likely given the evidence that some molluscs appear to show the fossilized soft-bodied animal remains. Perhaps the animals were killed by a load of fine mud from a land runoff, or river sediment, causing the burial. The sediments within the units where the shell seams are common often show a fine component of plant material indicating a landward origin. A supporting piece of evidence is the appearance of the usually fluviatile genus *Theodoxus*, it could also have been transported seaward with the land or river sediments.

Hickman (1976, p. 25–28) cites studies noting the increasing percentage of turrid species in modern neogastropod faunas with depth. Within the Reklaw fauna the turrid percentage of the fauna is about 26%, placing the bulk of the Reklaw faunas in the 0–20 m range, although probably at the deeper end since the turrid families represented are indicative of deep water (Hickman, 1976; Powell, 1966). The presence of abundant corals, bryozoans and bivalve suspension feeders also implies that the fauna must have lived in a normal marine environment. Purdy (1964) notes that suspension feeders are more common in sands, while *Nucula, Glycymeris, Chama* and *Postalia,* prefer a coarser substrate such as gravel, or shell hash, or a reef substrate. As the bulk of the Reklaw material is found within a sandy clay it might indicate some transportation of the material took place prior to final disposition. When bivales such as *Chama,* and *Plicatula* that prefer a hard



Text-figure 6.—Charts showing the relative abundance and diversity of species found in Ridge Creek and Joe Taylor Branch, and their inferred environment.

substrate have been found attached, they are always attached to a branching coral or serpulid gastropod mass, all of which usually shows signs of wear. All the *Cypraeorbis* species were found associated with rolled coral fragments, while the two complete specimens were embedded in very large masses of coral as though broken off from a reef. Several bivalve genera could indicate deeper water, notably *Hyotissa, Amusium,* and *Bathyarca,* although all of them are uncommon or rare in the Reklaw deposits. In conclusion it appears that most of the Reklaw fauna was deposited in an inner to middle neritic, 3–30 m, setting, with a component derived from a nearby reef. This setting is corroborated by Sans and Gaskill (1990) who find that the foraminiferal diversity maximum occurs at the top of a condensed section, and correlates with a maximum marine flooding surface. The inferred environment is a very shallow marine to marginal marine environment which deepens to an open-marine inner neritic setting.

REPOSITORY ABBREVIATIONS

In the systematic section the following codes are used:

ANSP	Academy of Natural Sciences in Philadelphia, PA, USA
AMNH	American Museum of Natural History, New York, NY, USA.
USNM	United States National Museum, Washington, DC, USA
PRI	Paleontological Research Institution, Ithaca, NY, USA
TBEG	Bureau of Economic Geology, Austin, TX, USA
UT-TMM	Texas Memorial Museum, Austin, TX, USA (repository of the type specimens of the Bureau of Economic Geology, Austin, Texas).
BMNH	Natural History Museum, London, England.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

For specific comparisons, the publications of previous workers on the Paleocene faunas such as Conrad, Lea, Harris, Aldrich, and Palmer, etc. were used and then in most cases verified by comparison with the holotype. With very few exceptions all dates and citations were verified by checking the original reference; those few that could not be verified are noted in the text. Not all *nomen translatum* and *nomen correctum* items have been verified for family and higher taxa.

The classification followed is that of Haszprunar (1988) for the archeogastropods with modifications by Dockery (1993); Ponder and Warén (1988) is followed broadly for the Caenogastropoda, Heterostropha and Euthyneura; Moore [Editor], (1964, 1969, 1971) for the Bivalvia and Cephalopoda; Steiner (1992) for the Scaphopoda.

Gastropods are described in the traditional North American orientation with the apex up (dorsal) and the aperture below (ventral). Morphological terms applied to gastropods are those defined in Moore (1960, p. I129–I135). Following Stenzel *et al.* (1957), bivalves are described with orientation of the hinge above and the commissure below; and the length as "the greatest dimension obtained by projecting the end of the shell onto the line of the hinge axis"; the height as "the greatest dimension obtained by projecting the umbonal region and the ventral margin onto a line at right angles to the hinge axis and within the plane of symmetry"; the width of a shell as "its greatest transverse dimension, generally the width of one valve is half the width of the whole shell". Remaining bivalve morphological terms and hinge-tooth notation are those used in Moore (1969, p. N56, pp. N102–N109). Scaphopods are described following Hodgkinson (1974), with the aperture anterior, apex (with smaller diameter than the anterior end) posterior, and the ventral face (line of maximum diameter) down.

Where species belong to new genera not found in the Gulf Coast and are clearly different from any previously known they were assigned a new taxon without hesitation. For the bulk of the species though, there are known related Sabine or Claibornian forms. The variability of the group could be ascertained either from Museum collections or the author's own collection. If a Reklaw species differed significantly in one or more primary characters from a similar species, it is usually defined as a new species. A primary character is used in the sense of what the original author, and any succeeding revisors, regarded as of primary importance in the definition of the taxon. For example, if a particular species was defined as always having two columella plications, and if all specimens of a similarly appearing Reklaw species had only one, then that would be a candidate for a new taxon. If, however, the Reklaw species had several more spiral lines on the whorls than a similar, but already known species, less weight would be given to that character if it was not constrained by the original author or revisors in some way. What constitutes a specific difference is of course subjective, especially for fossil faunas, and in fact is not even consistent from group to group. I have attempted to separate each group in the Reklaw fauna, using the same degree of variability for that group as already defined in the recent literature. In that task I have been particularly guided by how Palmer (1937), Harris (1937), Harris and Palmer (1946–1947), and Stenzel *et al.* (1957) treated the groups. If a subset of a species exhibits a character or characters that is not one of the primary ones, and yet shows consistent differences from the s.s. set, that subset is a candidate for a new subspecies. The same considerations apply when deciding whether a new genus should be defined, except in this case, I have been particularly influenced by how Wenz (1933–1944), Zilch (1959–1960), and Thiele (1931) have defined the generic groups. If a more recent treatment of the group in question exists that was also consulted. A question mark after a generic citation indicates that the species assigned to that genus differs, but not markedly so, in a primary character from the type species of that genus, or, that a primary character cannot be seen in the specimen due to breakage, or, because attached matrix obscures the feature. Question marks within synonymies are used in the same sense as used in Palmer and Brann (1965–1966).

For most taxa a large number of specimens was available for study, in the hundreds for some of the more common taxa. In a few cases new taxa are described from a small number of specimens, a practice not usually recommended, but in those cases the Reklaw taxa usually belonged to genera either not known in the Sabinian or Claibornian stages, or where one or more primary characters showed considerable differences from the most similar taxon.

One general problem that has to be dealt with when considering the Reklaw faunas is the question of size. This is considered in two parts: The first part considers those Reklaw species that come from what is regarded as an open marine environment. This would include the section from the base of the Marquez Shale Member to the top of the condensed section of Sams and Gaskell (1990). Subjectively, the Reklaw species would appear to be much smaller than that of similar Claibornian or Sabinian species. When comparisons are made between species for which large collections are available (for instance *Athleta*, *Ancilla*, and several turrid genera), the maximum size of the comparable species is usually between half and three-quarters of the maximum of the species from the other stages. The average size of the species collected from the Reklaw fauna appears to be significantly smaller than average sizes collected from the other stages. Part of this result is believed to be due to a collection bias. Within the Claibornian stage, fossils can be collected on the outcrops with ease, so the smaller specimens may be overlooked or not collected to the same degree as the larger ones. Within the Reklaw outcrops, the fossils are comparatively rare, so all specimens tend to be collected, regardless of size. Size has therefore rarely been used as a differentiating character in the comparisons of taxa between the stages. The second part is for those sections where Sams and Gaskell (1990) inferred the depositional environment as transitional to brackish water. This includes localities 6 and 7 where the size differences are much more pronounced than in the marine sections. Only one large species has been found here, a large *Venericor* clam, the remaining species are much smaller than comparable species from the open marine beds. Due to the different environment, size is regarded as a significant factor for species restricted to these beds.

When comparisons are made between gastropods, the number of whorls rather than size is used in inferring whether the specimen is a juvenile or adult. When comparing bivalves or scaphopods there is no equivalent easy way to distinguish the juveniles from species that are small in the adult stage. For some bivalves (for instance the nuculanids), the outline changes as the shell transitions from the juvenile to the adult, and that can be used to distinguish growth stages. For many bivalves (for instance corbulids and some venerids), where similar genera exist in the Sabinian and Claibornian stages, juveniles and adults were available for comparison, and growth stages could be inferred. For the scaphopods, the prominence of the apical notch in the family Gadillidae can indicate the growth stage, for other families the size must be relied upon.

Unless otherwise noted, the repository of all specimens noted in the *Material examined* sections, is in the author's collection. Type and most figured material is in PRI. Some extra material from the type series will also be deposited in the USNM and BMNH.

SYSTEMATICS

Phylum **MOLLUSCA** Linnaeus, 1758, p. 641

Class **BIVALVIA** Linnaeus, 1758, p. 669

Subclass **PALAEOTAXODONTA** Korobkov, 1954, p. 72

Order **NUCULOIDA** Dall, 1889a, p. 450

Superfamily **NUCULOIDEA** Gray, 1824, p. 241

Family **NUCULIDAE** Gray, 1843, p. 155

Genus **NUCULA** Lamarck, 1799, p. 87

Type species.—*Arca nucleus* Linnaeus, 1758, by monotypy. Recent in European seas.

Diagnosis.—Shell small, nacreous, trigonal to subcircular, inequilateral, anterior end longer than posterior; area behind umbo slightly to strongly depressed; two sets of chevron-shaped, close-set hinge teeth, the anterior set the larger; external surface generally smooth or concentrically striated; valve margins usually finely crenulate.

Remarks.—The genus is recorded from the Cretaceous onwards; recent representatives are deposit feeders and are found in both shallow and deep waters, both in sandy and mud substrates; the species is more characteristic of boreal and temperate waters. At least 21 species are recorded from the Paleocene and Eocene of the Gulf Coast.

Nucula cochlear, new species

Plate 1, figures 1–4

Description.—Shell very small, long and ovately elliptical. Width about 53% of length and 67% of height. Umbones at 80% of length, lying posterior to the middle; a low rounded ridge extends from there to the posterior extremity. A weak concavity is developed dorsally to the ridge, the valve margin where the ridge terminates is rounded and has an angular change of about 130°. The ventral margin is smoothly rounded with about eight crenulations per mm Lunule narrow, bordered by a low, rounded ridge, escutcheon lanceolate, poorly defined and moderate in size. Hinge line smoothly curved and hinge plate possessing about 17 anterior and nine posterior, long, slightly curved teeth. Resilifer concave, oblique towards the anterior margin and jutting downward. Pallial line indistinct, sinus sharply triangular with the apex pointing vertically upward. Sculpture of indistinct rounded undulations and radial lines, both becoming obsolete on the umbo.

Remarks.—Allied species are *Nucula (Nucula) mauricensis* Harris, 1919 from the Weches and Stone City formations, and *Nucula (Nucula) smithvillensis* Stenzel and Twining, 1957 from the Weches Formation; *N. mauricensis* is more inflated, has a smaller lunule and has the anterior and posterior hinge dentition meeting at an acute angle; *N. smithvillensis* is more elongate, less inflated, has a more pronounced umbonal ridge and shows no sign of any concentric sculpture.

Etymology.—The specific name refers to the large spoon-shaped resilifer which is uncommonly large for the genus.

Type information.—Holotype: left valve, PRI 30260; paratype: right valve, PRI 30261. Type locality: locality 20.

Material examined.—31 specimens, largest 6.1 mm long, 4.8 mm height, 1.7 mm width. Mean ratios: height/length .27, width/height .34, umbones/length .8.

Nucula spp.

Remarks.—Two further species of *Nucula* appear to exist in the Reklaw deposits. One of them is very much larger than *Nucula cochlear* n. sp., with a length of up to 10 mm It could be a gerontic specimen of that species but is uniformly ribbed over the entire dorsal surface and is more extended; both specimens of this species are badly crushed and preserved in a block of matrix from which they are impossible to remove. The second species is represented by one broken specimen which is much higher, has more prominent hinge teeth and is less elongate than *N. cochlear*. Neither of these two species can be further characterized until better material is obtained.

Superfamily **NUCULANOIDEA** H. and A. Adams, 1858, p. 544

Family **NUCULANIDAE** H. and A. Adams, 1858, p. 546

Genus **NUCULANA** Link, 1807, p. 155

Nuculana Link, 1807 (=*Leda* Schumacher, 1817, p. 173).

Type species.—Arca pernula Muller, 1771, by monotypy. Recent in North Polar seas and in the North Atlantic.

Diagnosis.—Shell moderately high, rostrate, with slightly anterior umbones and obtuse posterior keel, surface with concentric ornament. Lunule long, very thin, and sharp-ridged, escutcheon obscure, ligament pit very small and produced posteriorly, pallial sinus usually present.

Remarks.—Stewart (1930), stressed the importance of the small asymmetric chondrophore inclined posteriorly along the compressed series of taxodont teeth in the recognition of this genus. As with all Nuculanidae this is a deposit feeder.

Subgenus **JUPITERIA** Bellardi, 1875b, p. 20

Type species.—Nucula concava Bronn, 1831, by subsequent designation (Dall, 1898, p. 579). Pliocene of Italy.

Diagnosis.—"Shell small corbuloid, strongly inflated, subequilateral, bluntly rostrate, rostrum barely ridged; area behind umbo flattened but not depressed; sculpture consisting of obscure concentric rugae; hinge consisting of an anterior and posterior set of chevron-shaped teeth, approximately equal in length; chondrophore small, triangular, deep; pallial sinus shallow, the apex bluntly U-shaped." (Woodring, 1925, p. 18).

Remarks.—The subgenus has been recognized in the Paleocene of the S.E. and S. United States, the Pliocene and Miocene of Europe, and Recent in the West Indies.

Nuculana (Jupiteria) turgeo, new species

Plate 1, figures 13–16

Description.—Shell very small, height about 62% of length, strongly inflated, thickness 32–39% of height and umbones almost median at 42–50% of length. Anterior end smoothly rounded, posterior end very feebly rostrate; anteriodorsally rounded and with a slight indentation ventral to the rostrum. Lunule narrow, sunken and long, escutcheon lanceolate, margined by a rounded angulation and containing a medial line. About 15 posterior and 13 anterior chevron-shaped teeth. Pallial line indistinct, sinus broad, U-shaped and moderately deep. Posterior end with two rostral rays extending from the umbo to the limits of the rostrum. Surface smooth, shining and with irregular concentric incremental threads, obsolete anteriorly and posteriormedially then stronger again between the rostral rays.

Remarks.—This species combines some of the characteristics of both *Ledina* s.s. and *Calorhadia* s.s. The general shape with the rounded ends and smooth exterior places it near to *Nuculana (Jupiteria) smirna* (Dall, 1898) of the Kincaid Formation of Texas and the Wills Point Formation of Alabama, and *Ledina sp.* Harris and Palmer 1946 (p. 60, pl. 14, figs. 9–11) of the Jackson Group. Some specimens have a faint nacreous sheen internally. The shape of *N. (J.) turgeo* is similar to that of *Calorhadia houstonia* (Harris, 1895a) of the Cook Mountain Formation; however, the latter species is about twice the size, and possesses several short, radial lines near the rostrum. *N. (J.) turgeo* can also be distinguished from those similar forms by a strong inflation, shorter form and poorly rostrate outline. The rostral ridge varies from being well-defined and rounded, to being essentially obsolete. Two other similar genera which might be considered for this assignment are *Saccella* Woodring, 1925, and *Portlandica* Mörch, 1857. *Saccella* has a pointed rostrum and concentric folds, while *Portlandica* is more rostrate, has a heavier shell, and a shallow pallial sinus.

Etymology.—The specific name *turgeo* (Latin, swollen), refers to this species' very inflated form.

Type information.—Holotype: right valve, PRI 30262; paratypes: left valve, PRI 30263, double valve, PRI 30264. Type locality: locality 20.

Material examined.—55 specimens, the largest: 3.2 mm length, 2.0 mm high, 0.8 mm width. Mean ratios: height/length .62, width/height .35, umbones/length .48.

Subgenus **SACCELLA** Woodring, 1925 p. 15

Type species.—Arca fragilis Chemnitz, 1784 (= *Leda commutata* Philippi, 1844a), by original designation.

Diagnosis.—Shell small, high, slightly inequilateral, posterior end rostrate, pointed and unicarinate; umbo more or less central, a shallow groove extends from the umbo to the ventral margin at both ends of the valve; sculpture consists of strong concentric rugae; anterior and posterior series of teeth are approximately equal in length; apex of pallial sinus broadly U-shaped.

Remarks.—Palmer and Brann (1965), list seven species from the Paleogene of the Gulf and East Coast of the U.S. The subgenus appears to be uncommon in the Claibornian of Texas with the exception of the Weches Formation. It is widely distributed today.

Nuculana (Saccella) demissa, new species

Plate 1, figures 9–12

Description.—Shell very small, moderately inflated, height about 58% of length, umbones central. Anterior end smoothly rounded, posterior end rounded in young shells, feebly rostrate and ending in a blunt point in older ones. Lunule narrow, not well defined, escutcheon wider, bordered by a rounded ridge which ends at a rostral point, and containing another ridge running parallel to the margin for three-quarters of the length. About 16 posterior and 12 anterior chevron-shaped teeth. Surface smooth on the anterior third, ornamented medially with low and rather large concentric rounded folds which then become indistinct on the posterior third of the shell.

Remarks.—This species is easily distinguished from the only other similar Reklaw species *Nuculana (Jupiteria) turgeo* by its concentric folds. Larger specimens show a shallow depression in front of the rostral ridge running from the umbo to the ventral margin, while on the posterior side a smooth radial ray is formed by the cessation of the central folds. The comparatively large folds concentrated in the middle third of *N. (S.) demissa* can also distinguish this species from other Paleogene species. In outline, *Nuculana (Saccella) catasarca* (Dall, 1898) from the Cook Mountain Formation of Wautubbee, Mississippi, approaches this most closely although it is a very much more inflated species. This species has only been found in the indurated ledge at the top of the formation. The species may appear to be very small, and juvenile in aspect, but several adult species figured by Moore (1983, pl. 2) are within 1–2 mm of the size of *N. (S.) demissa.*

Etymology.—Referring to the low and indistinct character of the folds.

Type information.—Holotype: left valve, PRI 33070; paratype: left valve PRI 33071. Type locality: locality 7.

Material examined.—Four specimens, the largest, 4.2 mm length, 2.5 mm height.

Genus **LITORHADIA** Stewart, 1930, p. 37

Type species.—Leda acala Dall, 1898, by original designation. Bashi Formation, Sabine Group, Eocene of Alabama.

Diagnosis.—Resilifer narrow, oblique; posterior end produced; sculpture smooth or concentric; lunule sunken; ligamental pit wide; pallial sinus wide.

Remarks.—Gardner (1945), noted further the absence in *Litorhadia* of the posterior end double carination, and the obsolete or obtuse concentric sculpture so sharply developed in the group typified by *Calorhadia pharcida* (Dall, 1898). The group is particularly well developed in the Eocene of the Gulf Coast and is abundant at most of the Cook Mountain Formation localities in Texas. The genus ranges from the Eocene into the Miocene.

Litorhadia milamensis, new species
Plate 1, figures 5–8

Description.—Shell small, elongate, height 47–57% of length, umbones at 39–45% of length, inflation moderate at 25–43% of height. Anterior end smoothly rounded, posterior end produced and rostrate, the rostrum obliquely truncate. Umbones opisthogyrate, the dorsal margin from the umbones to the anterior end straight to feebly medially angulated, escutcheon and lunule long, the lunule bounded by a rounded angulation and bisected by a sharp ridge. Posterior portion of the valve bounded by two further rostral ridges. The inner surface of the valve with a rounded ridge, parallel to the dorsal margin and terminating in a prominent knob under the rostrum. Umbones with very fine concentric sculpture which disappear after about 1 mm and then reappear again more prominently with about ten undulations per mm.

Remarks.—This species can be distinguished from the other Reklaw species by the fine regular folds and narrow interstices. Gardner (1927), described the species *Leda atakta* from the Weches Formation at Smithville, referred to *Saccella* by Palmer and Brann (1966), and which shares many points of similarity with *Litorhadia milamensis.* This species appears to be the direct descendant of *L. milamensis* and is separated from it by its shorter, plumper form and larger flat and smooth inter-rostral area.

Etymology.—The specific name *milamensis* refers to Milam County.

Type information.—Holotype: right valve, PRI 30265; paratypes: left valve, PRI 30266, juvenile left valve, PRI 30267. Type locality: locality 20.

Material examined.—20 specimens: the largest 6.7 mm length, 3.4 mm height, 1.3 mm width. Mean ratios: height/length .52, width/height .34, umbones/ length .44.

Litorhadia undulata, new species
Plate 2, figures 1–4

Description.—This species, which has a generally similar outline to *N. (J.) turgeo* n. sp., can be distinguished by its more rostrate outline, the surface ornamentation of low rounded folds which become sharper towards the ventral margin and interstices wider than the folds. The folds die out irregularly towards the anterior end and sharply before a concave area preceding the first ventral ray.

Remarks.—This is the most common of the Reklaw *Litorhadia* species. Imprints referrable to this species have also been found in the ironstones of Wolf Den branch of Mud Creek, Robertson County, and Three Mile Creek in Milam County, Texas. The external ornamentation is so strikingly similar to those of *Nuculana jewetti* (Gardner, 1927) from the Weches Formation (not Cook Mountain Formation as given by Palmer and Brann, 1965, p. 219), that this species is undoubtably the precursor of Gardner's species. *N. jewetti* is shorter, lacks the concave area preceding the rostral ray and has a flat posterior ventral margin, not concave as in *Nuculana milamensis.* The folds of *L. undulata* vary quite considerably in size and at one extreme, approach the size of those of *L. milamensis.* The distinguishing feature is that the folds of *L. undulata* are the same size at all stages of growth while in *L. milamensis* the folds increase slowly in size with increasing growth. Worn specimens from Ridge Creek in Bastrop County possess the same outline as typical *L. undulata* from the type locality, although the surface ornamentation is finer and more effaced. None however has the fine regular pattern of *L. milamensis.*

Etymology.—The specific name *undulata* (Latin, wavy) refers to the prominent surface undulations.

Type information.—Holotype: left valve, PRI 30268; paratype, right valve: PRI 30269. Type locality: locality 20.

Material examined.—90 specimens: the largest 8.3 mm length, 4.6 mm height, 1.0 mm width. Mean ratios: height/length .55, width/height .22, umbones/ length .44.

Litorhadia valdefragilis, new species
Plate 2, figures 5–8

Description.—Shell very small, inflated, elongate, height 43–50% of length, umbones anterior at 35–40% of length. Outline of dorsal margin from umbo to tip of rostrum curved. Posterior rostral rays defined by two smooth diverging lines, the anterior ray defined by a slight swelling on the surface. Adult specimens have the anterior margin of the rostrum thickened into an elongate boss which projects into the interior past the hinge line. Resilium small and recessed. Lunule very feebly defined to absent, escutcheon long and lanceolate. Sculpture of well-defined rather widely-spaced, raised, concentric lines, the interstices with exceedingly fine lines of growth. The concentric lines are obsolescent before the anterior ray, and on the posterior end before the first rostral ray; the lines of growth continue undiminished in character over the rays.

Remarks.—The fine evenly-spaced concentric lines and the smooth rostral rays immediately distinguish this species from *Litorhadia undulata* and *Litorhadia turgeo.* The closest described relative is probably *Litorhadia? bastropensis* (Harris, 1895a) from the Weches Formation; *L. bastropensis* has concentric lines with wider interstices. . The species is more common than the recovered number of specimens would indicate but the extreme fragility of the shells accounts for its apparent rarity. The fine sculpture sets this species apart from known Nuculanidae of the Eocene of the Gulf Coast. I have found a similar, although smoother species in the Stone City Member that appears to be the descendant of *L. valdefragilis.* Even though the larger specimens of *L. valdefragilis* are still very small, they do not appear to be juveniles. Adult specimens of *Calorhadia* and *Litorhadia* are more elongated than the juvenile ones, because the rostrum in the adult specimens is much more developed. Specimens of *L. valdefragilis* greater than 2 mm in length have essentially the same proportions, suggesting they have reached their adult proportions.

Etymology.—The specific name *valde* (Latin, very much), *fragilis* (Latin, easily broken), refers to that feature of the shell.

Type information.—Holotype: left valve, PRI 30270, right valve, PRI 30296. Type locality: locality 5.

Material examined.—19 specimens, the largest 4.0 mm length, 2.0 mm height.

Litorhadia sp.

Plate 1, figure 17

Remarks.—Two specimens were obtained of a *Litorhadia* which is quite distinct. It possesses folds of the type found in *Litorhadia milamensis* but only over the anterior quarter of the shell, the rest of the surface being smooth with indistinct irregular undulations. The specimens are cemented in a block of matrix so the interior cannot be observed.

Figured specimen: A left valve, PRI 30552, from locality 12.

Material examined.—2 specimens, the largest 7.2 mm length.

Genus **ORTHOYOLDIA** Verril and Bush, 1897, p. 55

Type species.—Yoldia scapina Dall, 1889b, by original designation. Recent off the Brazilian coast.

Original diagnosis.—"Shell oblong, gaping, blunt or rounded at both ends, without distinct rostrum; no carina. Pallial sinus large and broad. Teeth numerous in both series. *O. scapina* [error for *scapinia*] (Dall) from off Brazil, and *O. salenoides* (Dall), from the West Indies." (Verril and Bush, 1897, p. 55).

Remarks.—A reasonably common genus in the more unctuous shales of the Cook Mountain Formation, and Stone City Member beds of Texas, but difficult to collect due to their fragility. The genus is known from the Eocene onwards. Recent species are deposit feeders and primarily boreal in their distribution.

Orthoyoldia psammotaea vivianensis

(Harris, 1919)

Plate 2, figures 9–10

Yoldia psammotaea var. *vivianensis* Harris, 1919, p. 73, pl. 25, fig 31.

Orthoyoldia psammotaea vivianensis (Harris). Stenzel, Krause and Twining, 1957, p. 55.

Original diagnosis.—". . . The variety "*vivianensis*" has much more prominent beaks and stronger sculpture than *psammotaea*. . . ." (Harris, 1919, p. 73).

Remarks.—The Reklaw specimens have about 22 anterior and 20 posterior teeth, compressed and chevron-shaped near the beaks and becoming spatulate and compressed parallel to the hinge towards the posterior end. Resilifer deep, widely triangular and set back beneath the hinge line. Surface sculpture of concentric lirations, 12–14 per mm., strong medially and indistinct at each end. The subspecies is only known from the Reklaw Formation in Texas and Louisiana.

Type information.—Holotype: PRI 4231, an external mold in ironstone showing the shape and some details of the sculpture. Type Locality: Reklaw Formation of Vivian, Caddo Parish, Louisiana. Figured specimen: PRI 30271, from locality 20.

Material examined.—12 specimens, the largest: 11.5 mm length, 5.5 mm height, 1.0 mm width, umbones/length .41.

Subclass **PTERIOMORPHIA** Beurlen, 1944, p. 144

Order **ARCOIDA** Stoliczka, 1871, p. xx

Superfamily **ARCOIDEA** Lamarck, 1809, p. 318

Family **ARCIDAE** Lamarck, 1809, p. 318

Subfamily **ARCINAE** Lamarck, 1809, p. 318

Genus **BARBATIA** Gray, 1840, p. 81

Type species.—Arca barbata Linnaeus, 1758, by subsequent designation (Gray, 1847a, p. 197). Recent in the Mediterranean.

Diagnosis.—Shell usually moderate to large in size, somewhat irregular in outline; moderately inflated; anterior end rounded, posterior end rounded or angulated with a keel; posterior slope rounded; byssal gape small. Sculpture usually of beaded radial ribs. Umbones anterior. Cardinal area narrow with five or more chevron-shaped ligament grooves; hinge straight; hinge teeth continuous in the young, separated by an edentulous gap in the adult. Ventral valve margin finely crenulated. Periostracum hairy.

Remarks.—Recent species are suspension feeders, most abundant in warmer seas ranging from the intertidal zone to abyssal depths; shallow water representatives are usually attached by a byssus. The genus ranges from the Jurassic to Recent.

Subgenus **ACAR** Gray, 1857, p. 369

Type species.—Arca gradata Broderip and Sowerby, 1829, by subsequent designation (Woodring, 1925, p. 37). Recent off the coast of Mexico and Central America.

Original diagnosis.—"Shell small to medium sized, trapezoidal in outline, posterior end keeled; byssal gape narrow; sculpture coarsely reticulate and imbricate; ligament area rhombohedral and for the most part opisthodetic; teeth like those of *Barbatia* s.s. but the anterior series is larger" (Gray, 1857, p. 369).

Remarks.—The genus is known from the Paleocene to Recent. Living members of this subgenus are restricted to tropical and subtropical waters. Palmer and Brann (1966), note only two in the Paleogene of the Gulf Coast.

Barbatia (Acar) salebrosus, new species
Plate 2, figures 11–12

Description.—Shell elongate, medium in size, height 23% of length, umbones anterior at 26% of length, flattened and slightly inrolled behind the hinge line. Hinge straight with six anterior and ten posterior teeth. Anterior dorsal margin rounded, ventral margin sinuous, concave medially and anteriorly, gape shallow, posteriorly regularly rounded. Sculpture of thick concentric very regular foliations, covered by radiating costae which are thickened and upturned at the end of the foliations. Posterior umbonal region delimited by a slightly thickened line of nodular costae. Umbonal slope sculpture of hook-shaped downturned costae, the entire surface additionally covered with raised lines forming a granular effect. Interior with low radial and concentric undulations corresponding to the external sculpture. Adductor muscle scars elliptical and elevated, edge flattened and crenate.

Remarks.—Only one species referable to section *Acar* is reported from the Gulf Coast, viz. *Barbatia (Acar) aspera* (Conrad in Wailes, 1854); that species ranges from the Middle Eocene Weches Formation through the Upper Eocene Jackson Group. The present species seems to be the precursor of *B. (A.) aspera*, but differs enough to warrant separation from it. *B. (A.) aspera* has a sharper umbonal ridge with a very noded summit, a concave post umbonal area, and little or no medial depressed area. A possible antecedent is a variety of *Barbatia cuculloides* (Conrad, 1833a) found at Bell's Landing, which has a somewhat similar although weaker sculpture, is more regular and has a weaker umbonal ridge than the Reklaw specimens.

Etymology.—The specific name *salebrosus* (Latin, roughness), refers to the rough external sculpture.

Type information.—Holotype: a right valve, PRI 30272, 14.2 mm in length. Type locality: locality 15.

Material examined.—Two specimens, the largest 19.0 mm length, 10.0 mm height (estimated), 6.0 mm width. Two further fragments were also obtained.

Subgenus **CUCULLAEARCA** Conrad, 1865a, p. 11

Type species.—Byssoarca lima Conrad, 1847, by subsequent designation (Stoliczka, 1871, p. 340). Lower Oligocene, Vicksburg Group, of Mississippi..

Diagnosis.—Elongate to obliquely subquadrate, subequal but generally much distorted, ventral valve margin deeply sinuated by a large byssal gape; cardinal area high, amphidetic; sculpture formed by fine to coarse subequal costae; hinge long, straight, teeth in continuous series in young, in adults divided in the middle by large gape, distal teeth conspicuously larger and oblique.

Remarks.—The subgenus ranges from the Upper Cretaceous to Recent. Living members of the subgenus live in warm seas.

Barbatia (Cucullaearca) reklawensis, new species
Plate 2, figures 13–14

Description.—Shell medium in size, height 60% of length, width 33% of height, umbones anterior at about 29% of length. Shape obliquely rhombohedral, larger posteriorly. Anterior end obliquely truncate at the ventral margin, rounded medially and truncate at the intersection with the straight hinge line. Posterior end rounded to produced medially. Posterior keel not noticeable, ventral margin concave at both ends, convex in the middle at the byssal gape. Sculpture consists of coarse concentric growth-resting stages crossed over by numerous ribs which on the umbo tend to bifurcate, wider on the posterior end, fine medially and somewhat larger again anteroventrally. Posterior umbonal region sharply delimited by one larger coarsely foliated rib, the sculpture more subdued on the umbonal slope than on the rest of the shell.

Remarks.—The holotype is 36 mm long, 22 mm in width and 8 mm height; four juvenile specimens were also recovered, the largest 19 mm in length. Height/length, width/height and umbones/length ratios were within 10% of each other for all specimens. This species differs from *Barbatia uxoripalmeri* Stenzel and Krause, 1957, in its flatter and more rhombohedral shape, the straight hinge line and the more subdued ornamentation. The coarse rib separating the concave umbonal slope from the rest of the sculpture is very reminiscent of genus *Arca* and this species has some characteristics of both genera. Juvenile specimens show little trace of the expanded umbonal rib, the areas delimited instead by a sharper angular change in the shell. One specimen was also found in the Newby member in Cherokee County, at locality 25.

Etymology.—The specific name *reklawensis* refers to the formation.

Type information.—Holotype: a right valve, PRI 30273; paratype: a juvenile left valve: PRI 30274. Type locality: locality 15. Paratype from locality 20.

Material examined.—14 specimens, the largest: 36.0 mm length, 22.0 mm height, 8.0 mm width, 10.0 mm umbonal length. Mean ratios: height/length .59, width/height .35, umbones/length .29.

Barbatia sp.
Plate 2, figure 15

Description.—One specimen obtained, in hard sandstone, of a *Barbatia* species whose rhomboidal outline is similar to that of *Barbatia rhomboidella subscopula* (Harris, 1919) from the Lisbon Formation. The specimen is very finely ribbed with 54 ribs, those on the medial and posterior area bifid.

Type information.—Figured specimen: PRI 30305, from locality 8, length:13.5 mm.

Genus **BATHYARCA** Kobelt, 1891, p. 213–214

Type species.—Arca pectunculoides Scacchi, 1834 by original designation. Recent in European Seas.

Diagnosis.—Shell minute, subglobose, inequivalve, left valve larger than right. Posterior carina obscure or lacking. Sculpture of radial costellae and concentric threads, slightly different on each valve. Ligament area narrow, hinge line straight, teeth short and oblique, posterior and anterior series separated by an edentulous gap. Margin of valve faintly fluted.

Remarks.—The genus ranges from the Eocene to recent with the living species confined to relatively deep water. All but a very few species are minute in size.

Bathyarca claibornica, new species
Plate 3, figures 1–4

Description.—Shell very small, asymmetrical, to 3.5 mm in length, highly inflated, hinge line about 80% of maximum length. Sculpture of fine radial gently rounded costae, the intercostal area with a fine sharp radial line; overriding the radial sculpture are fine concentric lines which bend towards the umbo as they cross over the costae, stronger over the area which is transitional to the weak umbonal slope; sculpture of the left valve slightly more prominent than the right. Cardinal area under the umbones margined by a smoothly curved line; ligament preserved as a small asymmetrical high triangle, the base of which defines the edentulous portion of the hinge line. Teeth eight or nine in number on the anterior side and six on the posterior side. Inner margin of valves coarsely crenate.

Remarks.—This species is unique in the American Eocene, the oldest previously described form being *Bathyarca hendersoni* (Dall, 1898) from the Bowden beds in Jamaica. The largest specimen, unfortunately broken after collection, was 3.5 mm in length. All remaining specimens are 2 mm or less in size. Cossmann suggested that *Arca lissa* Bayan, 1873, from the Lutetian of the Paris Basin was an ancestral Eocene *Bathyarca*; the Reklaw species is much closer to the holotype than that species.

Etymology.—The name notes the first occurrence of this genus in the American Claibornian.

Type information.—Holotype: a left valve, PRI 30275; paratype: a right valve, PRI 30276. Type locality: locality 20.

Material examined.—17 specimens. Maximum length, 3mm. Mean ratios: height/length .8, width/height .44, umbones/length .67.

Family **NOETIDAE** Stewart, 1930, p. 78

Subfamily **TRINACRIINAE** MacNeal, 1937, p. 458

Genus **PACHECOA** Harris, 1919, p. 46

Type species.—Trinacria (Pachecoa) cainei Harris, 1919, by monotypy. Middle Eocene, McBean Formation of Orangeburg, South Carolina.

Diagnosis.—Shell small, moderately to strongly inflated; oval, trigonal or cunate-rectangular, not gaping. Umbones median or closely so, opisthogyrate. Anterior smoothly rounded, posterior usually angular, rostral ridge well developed. Lunule not present, escutcheon very narrow. Hinge arcuate, anterior series of teeth usually slightly longer than the posterior set. Cardinal area small and elongate-triangular, situated entirely behind beaks, ligamental area elongate, oblique and anterior to beak. Sculpture of low concentric ribs and close-spaced radial ribs. Inner margins crenate or smooth.

Remarks.—Stenzel *et al.* (1957, pp. 61–65) give a detailed discussion on the validity of the name *Pachecoa.* The genus is restricted to the Eocene of the Gulf and Atlantic Coasts.

Pachecoa concentrica, new species

Plate 3, figures 7–10

Description.—Shell small, to about 4 mm in length, moderately inflated, cuneate-rectangular, umbones slightly anterior. Anterior and ventral margin smoothly rounded, posterior-dorsal margin nearly straight. Umbonal ridge rounded, the umbonal area flat towards the dorsal margin. Anterior teeth seven, posterior series five or six. Sculpture of low somewhat irregularly spaced concentric rounded ribs, radial sculpture almost entirely obsolescent, defined principally by a microscopic wrinkling on the margins of the ribs, slightly stronger on the umbonal slope. Inner margins of valves smooth.

Remarks.—This species is smaller than other species of *Pachecoa* and differentiated further by the obsolete radial sculpture and smooth inner margins of the valves. It appears to be the ancestor of *Pachecoa sabinica* (Harris, 1919), a higher and more triangular species with well defined radial and concentric sculpture and crenate valve margins. Both Lower Eocene representatives of this genus, *Pachecoa decisa* (Conrad, 1833b) "var." Clark and Martin, 1901, and *Pachecoa microcancellata* (Barry, 1942), have smooth inner valve margins. Another species from the same time interval is the Tallahatta species *Pachecoa (Pachecoa) catonis* Stenzel and Twining, 1957, from Alabama; this species is larger, has about twice the number of hinge teeth and has both radial and concentric threads generating a reticulate pattern on the main part of the disc.

Etymology.—The name *concentrica* notes the dominant character of the sculpture.

Type information.—Holotype: a left valve, PRI 30277; paratypes: PRI 30278, 30279. Type locality: locality 20.

Material examined.—23 specimens, the largest: 4.1 mm length, 3.1 mm height, 1.0 mm width. Mean ratios: height/length .76, width/height .32, umbones/length .41

Superfamily **LIMOPSOIDEA** Dall, 1895, p. 517

Family **GLYCYMERIDIDAE** Newton, 1922, p. 72

Subfamily **GLYCYMERIDINAE** Newton, 1922, p. 72

Genus **GLYCYMERIS** da Costa, 1778, p. 168

Type species.—*Glycymeris orbicularis* da Costa, 1778, by original designation. Recent, widely distributed in shallower waters of warm and temperate seas.

Diagnosis.—Shell heavy, equivalved, equilateral or subequilateral, suborbicular. Beaks almost straight or only very slightly incurved; hinge margin arcuate with two series of transverse teeth; ligament amphidetic. Exterior surface of valves concentrically or radially striate; valve margins crenulate; adductor scars almost equal.

Remarks.—Members of the genus are cosmopolitan in distribution and range from the Lower Cretaceous to Recent. Recent species are suspension feeders and often well adapted to life in a shell hash or gravel bottom environment.

Glycymeris sp.

Plate 3, figures 5, 6

Description.—Shell small, 6 mm., orbicular and dorsally very slightly trigonal. Beak very feebly prosogyrate, ligamental area small, at about 23% of length, triangular, with a few chevron-shaped grooves. Hinge highly arcuate with about eight teeth on either side. Outer surface very worn but still showing fine closely spaced radial lines.

Remarks.—The only complete valve obtained is apparently a left one but is very worn and is therefore not named specifically. The closest relative would seem to be *Glycymeris trigonella* (Conrad, 1833c) from the Gosport Sand of Alabama, a species of the same size but with a more circular outline.

Figured specimen: PRI 30280, from locality 20.

Material examined.—One specimen: 6.5 mm length, 6.5 mm height, 1.9 mm width.

Order **MYTILOIDA** Férussac, 1822, p. xvii

Superfamily **MYTILOIDEA** Rafinesque, 1815, p. 147

Family **MYTILIDAE** Rafinesque, 1815, p. 147

Subfamily **MYTILINAE** Rafinesque, 1815, p. 147

Genus **MYTILUS** Linnaeus, 1758, p. 704

Type species.—*Mytilus edulis* Gray, 1847a, by original designation. Recent in the North Atlantic.

Diagnosis.—Shell mytiliform, beaks terminal, lunule with radiating folds forming dysodont teeth on the anterior margin. Anterior retractor scar elongate, behind the umbo, anterior adductor small but distinct; margin not crenulate. Surface smooth or with radial ribs which are not bent in the dorsal direction.

Remarks.—The genus is known from the Upper Jurassic to Recent, and is cosmopolitan in distribution. The preferred habit of living members is colonial, attached with a byssus to rocks and seaweeds.

Subgenus **CRENOMYTILUS** Soot-Ryan, 1955, p. 23

Type species.—*Mytilus grayanus* Dunker, 1853, by original designation. Recent in the Indo-Pacific.

Diagnosis.—"Shell mytiliform with terminal umbones, lunule grooved and incurved, forming two or three large teeth usually obsolete in old specimens. Margins finely crenulated. Shell obliquely striated, especially distinct on the ventral surface. Resilial ridge compact; anterior adductor strong, showing a distinct thickened scar; anterior retractor scar elongate behind umbo; posterior adductor and retractor scars continuous." (Soot-Ryan, 1955, p. 23).

Remarks.—Several species are known from the Oligocene to Pliocene of the west coast of America. Only one recent species is known, *Crenomytilus grayanus* (Dunker, 1853), from the Philippines.

Mytilus (Crenomytilus) sp.

Plate 3, figures 13, 14

Description.—Shell moderate in size, smooth, brown in color. Dorsal area above the line defining the position of maximum inflation with faint radial lines, the remainder smooth except for lines of growth and shell thickenings which reflect growth resting stages. Margin of the valves minutely crenulated except near the umbo where a few larger teeth occur. Ligament a thin groove under the teeth on the anterior-ventral margin.

Remarks.—Mytilidae are not common in the Gulf Coast Eocene, only one species, *Hormomya hamatoides* Call, 1891, being described so far. The present species fits readily in *Crenomytilus* with the crenate edge and compact linear ligament area. Another species with crenate valve margins that may be superficially confused with a juvenile *M. (Crenomytilus)* sp. is *Crenella isocardioides* (Lea, 1833). This species is much smaller, thicker-shelled, lacks terminal umbones, and has typically one weak, projecting cardinal tooth.

Figured specimen.—A double valve, PRI 30281, from locality 4.

Material examined.—One partially crushed double valve specimen, 9 mm length.

Subfamily **CRENELLINAE** H. and A. Adams, 1857, p. 514

Genus **GREGARIELLA** Monterosato, 1883, p. 90

Type species.—*Modiolus sulcatus* Risso, 1826, by original designation. Recent from the Mediterranean.

Diagnosis.—Elongate species with anterior umbones, straight dorsal margin, angulated umbonal keel separating a coarsely sculptured dorsal part from a smoother ventral part. Radially striate or decussate anteriorly or posteriorly where the posterior striae end along an oblique line. Hinge with dysodont teeth both anteriorly and posteriorly, valve margins dorsally finely crenulate. Periostracum hairy with bifurcating hairs.

Remarks.—Members of this genus reportedly live in burrows in shell and coral. The genus is known from the Eocene to Recent.

Gregariella ridgei, new species

Plate 3, figures 11, 12

Description.—Shell very small, elongate rounded-subrectangular, dorsal side almost straight, ventrally with a shallow sinus, translucent brown in color, the prodissoconch whitish and sharply defined from the teleoconch. Sculpture of bifurcating radial lines covering the surface from the dorsal margin, to below the umbonal angulation, there covering about one quarter of the ventral slope. Radial lines overriden by incremental co-marginal growth lines and occasional undulations, stronger on the dorsal slope, there forming a latticed pattern. A few weak radial lines are seen again on the smooth ventral slope in the immediate neighborhood of the umbo. On the ventral slope the radial striae end in an irregular, more or less oblique line. Resilium elongate, relatively large, posteriorly with four or five larger teeth, anteriorly and beneath the umbo three larger teeth and a few smaller ones. Valve margins crenulate except above the resilium. Anterior muscle scar compressed-elliptical, the end situated directly under the beak, posterior scar bean-shaped and very indistinct.

Remarks.—This species is similar to *Gregariella arcaforma* H. E. Vokes, 1986, a species from the Miocene Chipola Formation of Florida. The Chipola species is two to three times the size, more modioliform and more evenly rounded at the anterior end than *G. ridgei.* This is the earliest report of the genus in America. Glibert and van de Poel (1965, p. 80), who treat *Gregariella* as a subgenus of *Musculus,* list three species from the Eocene of the Paris Basin. Of the three, only one as presently understood could be assigned to *Gregariella,* the Lutetian species *Gregariella arcaeformis* Cossmann, 1887.

Etymology.—Notes the locality, Ridge Creek, where the specimens were found.

Type information.—Holotype: PRI 33072, a left valve, length 5.2 mm, height 2.8 mm, thickness 1.8 mm; paratype: PRI 33073, a right valve. Type locality: locality 4.

Material examined.—Three specimens.

Superfamily **PINNOIDEA** Leach, 1819, p. 329

Family **PINNIDAE** Leach, 1819, p. 329

Genus **ATRINA** Gray, 1842, p. 83

Type species.—*Pinna nigra* Dillwyn, 1817, by subsequent designation (Gray, 1847a, p. 199). Recent in the Red Sea and Arabian Gulf.

Diagnosis.—Cuneiform or ham-shaped anisomyarian clams with large posterior adductor and a small or no anterior adductor. Shell large, broad, fragile, gaping posteriorly. Ligament in narrow groove extending the whole length of the hinge margin. Shell structure is internally nacreous to about two-thirds or three-quarters of the length, not divided by an internal sulcus, and externally with a prismatic layer of large calcite crystals at right angles to the surface.

Remarks.—The closely similar genus *Pinna* is distinguished from *Atrina* by its straight wedge shape and the division of the nacreous shell layer by a longitudinal sulcus. The clams live upright in sand or mud with the apical end attached by the byssus to a substrate. The genus is known from the Middle Jurassic to Recent.

Atrina? sp.

Plate 3, figures 15, 16

Remarks.—Five small fragments and one fairly complete valve were obtained. The smaller fragments are all from areas near the beak and show that near that point the shell must have been diamond-shaped in cross-section. Outline pinnate with one straight hinge margin and one sinuous margin. The large specimen shows a well-defined nacreous layer extending from the beak as a rounded lobe occupying about three-fifths the length of the shell. Anterior ventral slope and accessory carinal area with straight radial ribs, anterior dorsal slope with obsolete radial sculpture, from the dorsal carina originate numerous curved diverging ribs; these meet the ventral ribs in a narrow area near the ventral carina and generate a complex cross-hatch pattern. Distant from the beaks, sculpture of long irregularly sinuous rounded ribs. The diamond-shaped cross-section can separate this species from *Atrina gravida* (Harris, 1919) and *Atrina cawcawensis* (Harris, 1919), both from the Cook Mountain Formation.

Reference locality: Locality 20.

Material examined.—One fairly complete specimen, 55 mm in length; numerous fragments.

Figured specimens: Beak fragment: PRI 30548; specimen on matrix: PRI 30549.

Superfamily **PTERIDOIDEA** Gray, 1847a, p. 199

Family **PTERIIDAE** Gray, 1847a, p. 199

Genus **PTERIA** Scopoli, 1777, p. 397

Type species.—Mytilus hirando Linnaeus, 1758, by monotypy. Recent off the coast of England and southward through the Mediterranean.

Diagnosis.—Shell nacreous, inequivalve, auriculate, the left valve more inflated. Anterior auricle comparatively small, the posterior one ailiform. Exterior surface almost smooth; umbones low and sharp, hinge line straight. A single cardinal tooth under the umbones of each valve; one lateral tooth sometimes present.

Remarks.—The genus is known from the Triassic onwards. Recent members of the genus are found mainly in tropical and subtropical seas. *Pteria* fragments are common in the Claiborne outcrops in Texas but entire valves are rarely found due to their fragility. The type of the genus is characterized by a long extended posterior auricle, weak to inconspicuous dentition and a smooth surface. Harris and Palmer (1946, pp. 36–37) briefly characterized three sections for living *Pteria* but did not formally designate them. Only *Pteria* s.s. has been reported from the Tertiary of the Gulf Coast.

Pteria petropolitana, Stenzel and Twining, 1957

Plate 4, figures 1, 2

Pteria (Pteria) petropolitana Stenzel and Twining, *in* Stenzel, Krause and Twining, 1957, p. 81, 7, figs. 14–6, text fig. 12; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman) 1977, pp. 12, 20.

Original description.—"Right valve thin, nacreous, small (to 16 mm long). oblique (axis of disk making an angle of about 43 degrees with the dorsal margin; . . . moderately inflated. Umbones very small, anterior (at about 0.21 of height). Byssal notch small, shallow, and obtuse. Ventral margin broadly and smoothly arcuate, posterior margin sigmoid, descending below the posterior auricle at an angle of 76°. Dorsal margin long and straight. Anterior ear broken, probably angular, posterior ear long, produced into a narrow, pointed wing extending well beyond the posterior end of the disk. Ligament area long, exceedingly narrow. Toothlike swellings small, inconspicuous. Sculpture of obscure concentric growth wrinkles only." (Stenzel and Twining, *in* Stenzel *et al.,* 1957, p. 81).

Remarks.—None of the Reklaw specimens recovered has the posterior auricle present but this is probably due to poor preservation. The present species has the angle between the axis of the disc and the dorsal margin extremity equal to that of *P. petropolitana* and also has the very long ligamental area of that species. The latter feature differentiates *P. petropolitana* from other Tertiary species of the Gulf and Atlantic coastal plain.

Figured specimens.—Left valve (in matrix), PRI 30282; right valve, PRI 30283; from locality 7.

Material examined.—14 specimens, the largest: 26.2 mm in length, 16.7 mm height.

Pteria sp.

Remarks.—One specimen appears different from *P. petropolitana* in possessing a semi-quadrate disc shape and a smaller anterior auricle. No posterior auricle is present, and although it may be a worn specimen an examination of the growth lines near the dorsal margin shows no indication of the change in angle that would imply one was originally present. The specimen is on the surface of a block of matrix and without an examination of the interior it will not be named here.

Order **PTEROIDIA** Newell, 1965, p. 17

Suborder **PTERIINA** Newell, 1965, p. 17

Superfamily **PECTINOIDEA** Rafinesque, 1815, p. 148

Family **PROPEAMUSSIIDAE** Waller, 1972, p. 249

Genus **AMUSIUM** (Bolton) Roeding, 1798, p. 165

Type species.—Ostrea pleuronectes Linnaeus, 1758, by subsequent designation (Hermannsen, 1846, p. 47). Recent in the Indo-Pacific.

Diagnosis.—Shell usually large, thin, suborbicular, slightly inflated, right valve slightly more so than the left; radial sculpture absent on the exterior; auricles subequal; byssal notch small, chondrophore moderately large, shallow and flanked by two cardinal crurae. Interior with narrow ribs not extending to the ventral margin.

Remarks.—Recent members are carnivores, living on small crustaceans in mud-bottom environments (Knudson, 1967, p. 327–329). The genus is known from the Cretaceous to Recent.

Subgenus **PROPEAMUSIUM** de Gregorio, 1884, p. 119

Type species.—Pectin (Propeamusium) ceciliae de Gregorio, 1884, by original designation. Miocene of Italy.

Diagnosis.—Valves rather flattened, thin, polished; usually gaping along lateral margins; valves concentrically sculptured, left sometimes radially striated; byssal notch slight to moderate; about nine internal ribs which do not extend to the margin.

Remarks.—Only two species referable to *Propeamusium* have been recovered from the Gulf Coast, and one of them,—*Amusium (Propeamusium) squamulum* (Lamarck, 1806), is a species originally described from the Paris Basin. Most living members of the group are widely distributed, small, and live in deep water.

Amusium (Propeamusium) zinguli, new species

Plate 4, figures 10, 11

Description.—Shell very small, ovate to 3.6 mm in length, 3 mm width, slightly convex. Sculpture of about 56 riblets crossed by fine concentric imbricated threads, more widely spaced towards the valve margins. A few riblets tend to develop in the interstices between the main ones. Interior with nine ribs extending almost towards the valve margins. Pallial sinus large and rounded, extending almost to a line connecting the auricular margins.

Remarks.—A similar form and also of similar size is *Amusium (Propeamusium) alabamensis* (Aldrich, 1886) from the Midway Group of Alabama. That species has a few weak radial lines in the center of the disc and on the anterior side of the shell. Tertiary members of this group, even when adult, are typically less than 15 mm in size.

Etymology.—This species is named in honor of paleontologist Dr. Richard Zingula, formerly of Exxon Corporation, Houston.

Type information.—Holotype: a left valve, PRI 30284; paratype: PRI 30285. Type locality: locality 4.

Material examined.—Seven specimens, the largest: 4.5 mm length, 4.3 mm height, 0.7 mm width. Mean ratios: height/length .96, width/height .16, umbones central.

Family **PLICATULIDAE** Watson, 1930, p. 29

Genus **PLICATULA** Lamarck, 1801, p. 132

Type species.—Spondylus plicatus Linnaeus, 1758, by subsequent designation (Schmidt, 1818, p. 61). Recent in the Indo-Pacific.

Diagnosis.—Shell inequivalve, flattened or slightly convex, trigonal to subcircular, commonly irregular, attached by umbone of right valve. Exterior surface generally plicate or foliate. Ligament internal, located in a central cartilage pit between two large transversely striate crurae; valve margins fluted.

Remarks.—Only a few species of *Plicatula* have been described from the Tertiary of the coastal plain. At several places in the Wheelock and Landrum Members of the Cook Mountain Formation in Texas, *Plicatula filamentosa* Conrad 1833a forms a shell bed to the exclusion of almost all other species. Good exposures may be seen in the lowest beds of the Wheelock Member on the banks of the Little Brazos River near Bryan, and exposures in the Landrum Member in the banks of Hurricane Bayou near Crockett. Modern representatives are suspension feeders and usually attached to rocks or other hard substrate, primarily in warm tropical seas. The genus ranges from the Middle Triassic to Recent.

Plicatula pustula, new species

Plate 4, figs. 3, 4

Description.—Shell small to medium sized, the largest specimen 26 mm. Shell form very irregular, in juvenile specimens strongly tumid and with predominantly concentric growth lines; beyond a particular growth stage of ca. 10 mm in size the shell flattens out and the outer surface develops about eight to ten very rough irregular radial lamellose costae. Resilium pit small, crurae diverging in young specimens, massive, projecting, and tending to become parallel in large ones. Adductor scar prominent, moderate in size, orbicular, and slightly posterior. In the largest specimens the scar is elevated to a prominent projecting boss. Interior valve margins obscurely crenulated.

Remarks.—The irregular character of the shell surface is more reminiscent of the Ostreinae but the hinge characters place it in the Plicatulidae. *Plicatula? louisiana* Harris, 1946, *Plicatula creola* Allen, 1970 both from the Moodys Branch Formation, and an undescribed form from the Cook Mountain Formation in Texas, are other species of this group having a similar early inflation, that later flattens out. Most specimens are fragmentary or worn, but a few specimens do show a minutely spinose surface, a feature also seen on *P. creola*; the prominent adductor scar and heavy hinge teeth can serve to distinguish *P. pustula* from that species. The common *P. filamentosa* is a more regular and less inflated species. Two specimens are attached over a large portion of the exterior, a character typical of the Ostreidae, while *Plicatula* is usually attached by the umbones.

Etymology.—The specific name *pustula* (Latin, pimple), refers to the prominent adductor scar in the shell's interior.

Type information.—Holotype: a right valve, PRI 30286; paratypes: PRI 30287, 30288. Type locality: locality 20.

Material examined.—38 specimens, numerous fragments. Dimensions of the largest: 24.0 mm length, 26.0 mm height, 8.0 mm width (including dentition).

Suborder **OSTREINA** Férussac, 1822, p. xxxix

Superfamily **OSTREOIDEA** Rafinesque, 1815, p. 21

Family **GRYPHAEIDAE** Vyalov, 1936, p. 19

Subfamily **PYCNODONTEINAE** Stenzel, 1959, p. 16

Genus **HYOTISSA** Stenzel, 1971, p. N1107

Type species.—*Mytilus hyotis,* Linnaeus, 1758, by original designation. Recent in the Indo-Pacific.

Remarks.—The genus ranges from the Late Cretaceous to Recent and is restricted to deeper waters of the open sea where salinity and temperature stay within a narrow range.

Hyotissa offemanae, new species

Plate 4, figures 5–9

Description.—Shell to about 6 cm long and high, shape circular to moderately higher than long, rarely falcate. Left valve moderately capacious, attachment area 50% of valve area or more. Shell commissure strongly plicate, plicae rounded to sharp-topped, not divaricate; occasional scale-like extensions on ribs. Interior with oval attachment scar, higher than long. Resilifer large, tip curved to the left, set at angle of about 60° to valve margins. Chroma long, often occupying more than 50% of the valve margins. Right valve concentrically imbricate, sometimes with low radial plications, commissure not plicate. Exterior of both valves prominently vesiculate where worn.

Remarks.—Stenzel (1953, p. 75–76) noted a marine faunule in the Newby Member of the Reklaw Formation containing a deep water pycnodont oyster. The locality was visited in 1988 and found to be very weathered, but *H. offemanae* could still be collected where it outcrops on several indurated ironstone/clay ledges. In the Marquez Member at Joe Taylor Branch and Ridge Creek, juvenile specimens of a pycnodont occur, recognizable by the vesicular shell structure, but they are too small to assign confidently to *H. offemanae*. The subfamily occurs very rarely in the Claiborne and is only represented by one described species *Pycnodonte (Pycnodonte) trigonalis* (Conrad *in* Wailes, 1854). Palmer and Brann (1966) assigned it to *Gigantostrea* but the vesicular shell structure indicates the assignment is in error. In the Claiborne Group, the author only knows of two other *Pycnodonte* specimens of a new species from the Wheelock Member. The closest described species is *Ostrea tacalensis* Hodson, 1927, from the Eocene/Oligocene of Venezuela, which is a more elongate species with a smaller attachment area than *P. offemanae*. A somewhat similarly sculptured species is *Ostrea crenulimarginata* Gabb, 1860, from the Clayton Formation of Alabama and the Kincaid Formation of Texas; this species is more elongate and lacks the radial plications on the upper valve. The absence of the vesicular shell structure in *O. crenulimarginata* also precludes placement in the pycnodont group of oysters.

Etymology.—Honoring Irene Offeman, one of the founding members of the Paleontology Section of the Houston Gem and Mineral Society whose enthusiasm and dedication to paleontology has inspired the Society's members.

Type information.—Holotype: a left valve, PRI 30554; paratypes: PRI 30555, 30556. Type locality: locality 25.

Material examined.—30 more or less fragmentary specimen, the largest 65 mm length.

Subclass **HETERODONTA** Neumayr, 1883, p. 5

Order **VENEROIDA** H. and A. Adams, 1858, p. 347

Superfamily **LUCINOIDEA** Anton, 1839, p. 6

Family **LUCINIDAE** Fleming, 1828, p. 409

Subfamily **MILTHINAE** Chavan, 1969, p. I501

Genus **ANODONTIA** Link, 1807, p. 156

Type species.—*Anodontia alba* Link, 1807, by monotypy. Recent in the West Indies.

Diagnosis.—"Shell of large to very large size, thin, longer than high, strongly inflated, anterior expansion small or moderate. Surface sculpture concentric, fine to distinct, with irregularly spaced growth rings; dorsal areas faint to distinct. Lunule long, shallow, variable in shape. Ligament external or slightly inset. Anterior adductor scar variable in shape and position; posterior adductor scar elliptical. Anterior pedal retractor scar separate from adductor, posterior one not evident. Pallial blood vessel line scar present; inner ventral margin smooth." (Bretsky, 1976, p. 302).

Remarks.—A suspension feeder, which is often able to tolerate extremely poor conditions although the preferred habitat is near shore, in sandy, grassy environments. The genus is known from the Paleocene to Recent.

Subgenus **EOPHYSEMA** Stewart, 1930, p. 186

Type species.—Lucina subvexa Conrad, 1833b, by original designation. Eocene, Gosport Sand Formation? (*cf.* Bretsky, 1976, pp. 305–306) of Alabama.

Diagnosis.—"Shell, thin, size very small to medium, larger than high, moderately inflated. Surface sculpture predominantly concentric, with fine radials. Dorsal area faint to distinct. Lunule long wide, triangular, shallow. Ligament external. Anterior adductor scar small, bent away from the pallial line, posterior adductor round. Anterior pedal retractor scar not evident. Hinge plate narrow, edentulous or with obsolete anterior and posterior laterals, and with one cardinal in the right valve, two in the left valve. Inner margin smooth." (Bretsky, 1976, p. 305).

Remarks.—The subgenus ranges from the Paleocene to Recent. Living representatives live in tropical and subtropical waters.

Anodontia (Eophysema) reklawensis, new species
Plate 5, figures 1–4

Description.—Shell small, height 92% of width and moderately inflated, thickness about 24% of length. Sculpture of fine and almost regular concentric lamellae which form short pointed nodes at the dorsal ends of the shell. The interstices of the lamellae show fine irregular radial striae of various lengths which continue over the lamellae. Lunule triangular, long and depressed. Anterior adductor scar lengthened and in the middle bent away from the pallial line, posterior adductor scar elliptical, anterior pedal scar round and separate, posterior one not noticeable. Left valve with one thin cardinal, pointing upward near the dorsal end and situated next to a triangular socket; right valve with bifid cardinal. The only prominent lateral tooth is the anterior one in the right valve.

Remarks.—Two species and varieties referable to *Eophysema* have been described from the Paleogene of the Southern Embayment, *Anodontia (Eophysema) subvexa* (Conrad, 1833b) and *Anodontia (Eophysema) ozarkana* (Harris, 1897b). Apart from its far larger size, *A. (E.) subvexa* is a relatively solid shell with a sculpture of low rounded undulations and a pitted interior. A closer species is *A. (E.) ozarkana,* but that has a more rounded profile, has more concave ventral hinge margins, and has a somewhat irregular sculpture of low undulations, rarely foliated.

Type information.—Holotype: left valve, PRI 30289; paratype: right valve, PRI 30290. Type locality: locality 20.

Material examined.—13 specimens, the largest: 7.0 mm length, 6.6 mm height, 1.8 mm width. Mean ratios: height/length .92, width/height .26, umbones central.

Anodontia (?) sp.

Remarks.—One specimen referable to *Anodontia* but different from the previously described species was found. This specimen is larger, somewhat anteriorly produced, has a longer ligamental groove, and a straight anterior adductor scar. Externally this species is smoother and shows none of the incremental radials that are a characteristic feature of *Eophysema.* It is possible this is a juvenile specimen of *Anodontia? augustana* Gardner, 1951, a species from the Tallahatta Fomation of Alabama and the Congeree Formation of South Carolina. The two species share a similar outline, an edentulous hinge, and the radiating lines on the interior which Gardner (1951, p. 10) mentioned occurring on interior molds of *A.? augustana.*

Superfamily **CHAMOIDEA** Lamarck, 1809, p. 89

Family **CHAMIDAE** Lamarck, 1809, p. 89

Genus **CHAMA** Linnaeus, 1758, p. 691

Type species.—Chama lazarus Linnaeus, 1758, by subsequent designation (ICZN opinion 484, 1957). Recent in the Indo-Pacific.

Diagnosis.—Typically sessile, attached by the left valve; beaks dextrally coiled; ornamentation spinose; comarginally foliated or lamellose. Lunule absent, ligament narrow and set in a deep groove. Adductor scars large, rough, and subequal. Interior of some species often pitted.

Remarks.—The animals are epifaunal, adapted for life on hard substrates; most species have a low tolerance to salinity changes. The genus ranges from the Paleocene (doubtfully the Upper Cretaceous) to Recent.

Chama taylorensis, new species
Plate 5, figures 5–6

Description.—Shell small, suborbicular. Right valve with irregular concentric rows of foliations which become progressively coarser, more pronounced and spinose towards the posterior ventral area. The spines are convex above, grooved below and tend to curve upward from the shell surface. The left valve with larger foliations and fewer spines. Right valve dentition obsolete anteriorly, posteriorly with a pronounced ligamental pit, 3b and PI large. The left valve with two very large teeth, the others obsolete. Beaks strongly incurved and spirogyrate. Except for the area under the beak, the interior of both valves is strongly pitted, that of the left valve is also linearly striate near the pallial line.

Remarks.—Chama taylorensis differs from the Cook Mountain Formation species, *Chama harrisi* Gardner, 1927, in possessing foliations that are irregularly spinose at the edges, particularly so at the ventral margin. The external sculpture of *C. harrisi* is predominantly radial, with the spines arranged on radial, sometimes bifurcating ribs. *Chama monroensis* Aldrich, 1903b, another species from the Cook Mountain Formation, possesses prominent foliations that are upturned at the edges. These foliations are not spinose, and have impressed radial lines that are arranged in pairs. An undescribed species, similar in many respects to *C. monroensis* is reasonably common in the Cook Mountain Formation of Texas, and may be distinguished by its totally smooth foliations. A closer species than either *C. harrisi* or *C. monroensis* is *Chama (Psilopus) mississippiensis* Conrad, 1848, from the Vicksburg Group. This species has radially arranged spines on the edges of the foliations. The Reklaw species can be distinguished from all of the preceding species, by the strongly pitted interior of the valves, the fairly regular, comarginal foliations, and the irregularly placed spines. Eocene species of *Chama* are usually small, most figured species being within a range of 8–20 mm.

Type information.—Holotype: left valve, PRI 30294; paratype: right valve, PRI 30295. Type locality: locality 20.

Material examined.—33 specimens, the largest: 12.2 mm length, 10.0 mm height, umbones at about 26% of length.

Superfamily **CARDITOIDEA** Fleming, 1820, p. 668
Family **CARDITIDAE** Fleming, 1820, p. 668
Subfamily **VENERICARDIINAE** Chavan, 1969, p. N554
Genus **VENERICOR** Stewart, 1930, p. 155

Type species.—Venericardia planicosta Lamarck, 1799, by original designation. Eocene of the Paris Basin and the Bracklesham beds of England.

Diagnosis.—Shell large, heavy; outline trigonocordate. Umbones inflated, anterior extremity short and obliquely rounded, posterior lateral margin slightly truncate. Lunule narrow and long delimited by a groove; escutcheon not defined. Earliest ribbing narrow, sharp, and crenate; adolescent and early adult ribs anteromedially flat-topped, the ribs wider than the interfaces; near the margins the collabral growth lines are prominent and often become dominant in large specimens. Hinge plate high and trigonal; anterior cardinal thin and lamellar, medial one heavy, posterior one lamellar and parallel with the inner margin of the nymph. Pallial line ragged and set back from the crenate valve margins.

Remarks.—The genus ranges from the Paleocene to the Oligocene.

Venericor densata reklawensis, new subspecies
Plate 6, figures 1–4

Venericardia (Venericor) densata Gardner and Bowles, 1939, p. 154.

Description.—The Reklaw specimens are ovate-triangular in outline, lunule sharply notched at the margin in larger specimens. Hinge plate smaller, margin straight to weakly sinuous, anterior cardinal is broad, flattened and almost vertical. The umbonal rib sculpture is T-shaped, rounded serrate in form, barely overhanging and dying out earlier than *densata* s.s.

Remarks.—The combination of smaller hinge area, ovate-triangular outline and notched lunule shell margin will distinguish this subspecies from typical *V. densata.* In a comparison between specimens from the Weches Formation, Stone City, Landrum, and Wheelock members of the Cook Mountain Formation in Texas, the following further differences were noted: Weches specimens have similar hinge characteristics but a regularly rounded outline; Stone City specimens possess a thicker obliquely inclined anterior tooth, costal nodes over the entire umbo, sometimes a similar outline, but a much larger hinge area; Landrum and Wheelock specimens have a larger hinge and have a vertically compressed outline. Stenzel (1953, p. 78) reports an abundance of *Venericardia planicosta* Lamarck in the Newby Member in the Tyler Basin of east Texas that is referable to this subspecies.

Type information.—Holotype: left valve, PRI 30296; paratype: right valve, PRI 30297. Type locality: locality 20.

Material examined.—48 specimens, the largest 5.95 cm length, 5.68 cm height, 1.91 cm thickness. Mean ratios: height/length .95, width/height .39, umbones/length .31.

Subfamily **CARDITESINAE** Chavan, 1969, p. N556

Genus **CLAIBORNICARDIA** Stenzel and Krause, 1957, pp. 104–105

Type species.—Cardita alticostata Conrad, 1833c, by original designation. Eocene, Gosport Sand Formation of Alabama.

Diagnosis.—Venerids with highly inflated shell, high degree of posterior and posterio-ventral elongation and generally inflated beaks. Ornamentation of radiating noded or terraced costae, tripartite in cross-section. Right valve dentition with a right blade-like anterior lateral (3a), which is a continuation of the dorso-anterior point of the medial cardinal (3b), and dorsal to the socket for the left-valve anterior cardinal tooth; socket narrowly or broadly triangular in shape. Dorso-ventral cross-section a fairly regular spiral which tends to flatten out as it approaches the ventral margin.

Remarks.—The genus ranges from the Lower Eocene to the Oligocene.

Claibornicardia linguinodifera milamensis, new subspecies

Plate 5, figures 11, 12

Description.—Shell small in size, quadrate in outline with strongly inrolled beaks. Right valve dentition: cardinal tooth 3a small, and blade-like, situated just left of 3b; cardinal tooth 3b blunt at the apex, sinuous; cardinal tooth 5b absent. Left valve dentition: cardinal 2a horizontal blade, flat ventrally, rounded-triangular dorsally; cardinal tooth 4b long and moderately sinuous. Ornamentation of 23–25 ribs that are tripartite in shape except on the posterior slope. Costal nodes flattened and tongue-like, paracostals terraced with rounded corners and where these are large enough similarly rounded in concert with the central nodes. Growth lines very marked and regularly wrinkled within the intercostals.

Remarks.—This subspecies is very likely intermediate in evolutionary position between *C. linguinodifera* and *C. coloradonis coloradonis* Heaslip, 1968 from the Weches and Bashi Formations respectively. It has very similar ornamentation to *C. linguinodifera* while possessing the outline of *C. c. coloradonis*. This new subspecies is less inflated, has the umbones more centrally placed, and is more elongate along the dorso-ventral axis than either of the latter two species.

Type information.—Holotype: right valve, PRI 30298; paratype: left valve, PRI 30299. Type locality: locality 20.

Material examined.—17 specimens, the largest: 14.5 mm length, 15.0 mm height, 4.9 mm width. Mean ratios: height/length 1.05, width/height .32, umbones/length .36.

Claibornicardia coloradonis subsp.

Plate 5, figures 7–10

Venericardia (rotunda?) var. *coloradonis* Harris, 1919, p. 81, pl. 29, fig. 9; Harris, 1946, p. 68; Palmer and Brann, 1965, p. 341.

Venericardia (rotunda) varying toward *trapaquara* Harris, 1919, pp. 80–81, pl. 29, figs. 6, 7.

Venericardia rotunda Lea, Plummer, 1933, pp. 641, 811–812, pl. 8, figs. 7a, 7b.

Venericardia trapaquara Harris (in part), Harris, 1919, pp. 81–82, pl. 30, figs. 6–7, 9.

Venericardia trapaquara subsp. *texalana* Gardner, 1927, pp. 370–371, figs. 24–27; Renick and Stenzel, 1931, p. 108; Stenzel et al., 1957, p. 106; Harris, 1946, p. 68 (variety *texalana* Gardner).

Description.—"Similar in general characteristics of shape and dentition to *V. (C.) linguinodifera,* but differs in higher degree of postero-ventral elongation and more highly developed posterior truncation, smaller lower umbones, and less closely or regularly arranged tongue-like costal nodes" (Heaslip, 1968, p. 100).

Remarks.—In the Texas Memorial Museum collections are venericards very close to *Claibornicardia coloradonis texalana* Gardner, 1927 from the Lower Weches Formation, differing in having a higher degree of postero-ventral elongation, about 20 ribs as opposed to about 25, and a dental pattern that is more similar to the *Claibornicardia linguinodifera* Heaslip, 1968, group from the early Eocene Bashi Formation. The exterior ornamentation is the same as *C. coloradonis texalana.* The specimens are from the Devil's Eye locality, where the exact stratigraphic level is not known.

Type information.—Figured specimens: left valve: TMM 8482, right valve: TMM 8483. Type locality: locality 11

Material examined.—Seven specimens, the largest 21.0 mm length, 18.5 mm height, 6.0 mm width. Mean ratios: height/length 1.02, width/height .39, umbones/length .25.

Superfamily **MACTROIDEA** Lamarck, 1809, p. 318

Family **MACTRIDAE** Lamarck, 1809, p. 318

Subfamily **MACTRINAE** Lamarck, 1809, p. 318

Genus **TENUIMACTRA**, new genus

Type species.—Tenuimactra hodgkinsoni, new species.

Diagnosis.—Shell small, ovate-trigonal, moderately to highly inflated. Sculpture concentric only. Right valve hinge with small resilial socket, anterior edge bounded by a prominent raised tooth, posteriorly with relatively large inverted V-shaped cardinal, set almost parallel to the hinge margin. Anterior laterals absent, posterior laterals very small to obsolete. A deep furrow runs from the umbo to the posterior end of the hinge area. Eschutcheon weakly defined by an impressed line.

Remarks.—Externally these specimens look similar to venerids but the hinge is relatively simple with a resilial socket, and an inverted V-shaped cardinal. The anterior-dorsal hinge margin of *Tenuimactra* is smooth and rounded, very different from the hinge furrow and anterior lateral teeth of most representatives of that family and the resilial socket is very small in comparison with the V-shaped cardinal of most Mactridae. The lack of lateral teeth is similar to *Lutraria* s.s. although in that genus the valve shape is prominently elongate and lacks an eschutcheon. Stenzel, Krause, and Twining 1957, report only one mactrid, *Kymatox* Stenzel and Krause, 1957, (=*Pteropsis* Conrad, 1860) from the Stone City Member. *Kymatox* has a sculpture of broad concentric undulations, a left valve with a prominent posterior lateral tooth and a thin, large, upturned hinge plate; the right valve with two cardinal teeth, and two strong posterior lateral teeth.

Etymology.—Tenui (Latin, simple) *mactra*-like, notes the very simple hinge characteristics.

Tenuimactra hodgkinsoni, new species

Plate 6, figures 5–8

Description.—As in the generic diagnosis.

Remarks.—All specimens were found attached to blocks of sandy-glauconitic matrix, are extremely delicate and had to be coated with hardener. The two specimens whose hinge was examined were first embedded in wax for stability before preparation took place and this has darkened the shell in places. The interior of both prepared specimens shows a blue colored band set back and parallel with the hinge margin. In the best-preserved specimen this band also changes direction at the anterior end as though defining a pallial sinus. The color is not believed to have any connection with the pallial sinus. Although only discerned with greatest difficulty, the pallial line appears as a reflective band parallel to most of the ventral margin; muscle scars not seen but may be obscured by the discoloration by the wax. The best specimen (now cemented to the wax base) shows a very close external resemblance to *Dermatomya? harrisi* Weisbord, 1929, from the Miocene of Colombia. The interior of *Dermatomya*, however, is nacreous or subnacreous.

Etymology.—The specific name honors Dr. Kenneth Hodgkinson, paleontologist and researcher on the Gulf Coast Tertiary Mollusca.

Type information.—Holotype: a right valve, PRI 33074, 6.7 mm length, 5.9 mm height; paratypes: PRI 30443-30446. Type locality: locality 4.

Material examined.—Four specimens, the largest (somewhat crushed), 16.3 mm length, 12.5 mm height.

Superfamily **SOLENOIDEA** Lamarck, 1809, p. 319

Family **SOLENIDAE** Lamarck, 1809, p. 319

Genus **EOSOLEN** Stewart, 1930, p. 290

Type species.—Solen obliquus Deshayes, 1860, by original designation. Eocene of the Paris Basin, France.

Diagnosis.—Shell elongate flattened, hinge with one tooth in each valve. Anterior end with an external oblique groove. Beaks at extreme anterior end.

Remarks.—According to Stewart (1930), this genus is restricted to the Eocene. Modern representatives of the family live upright in sand or mud in nearshore environments.

Eosolen shirleyi, new species

Plate 5, figure 13

Description.—Shell moderate in size, straight posteriorly and medially, slightly curved on the anterior quarter. Posterior end very slightly oblique and smoothly rounded, anterior end characterized by a deep oblique sulcus. Surface smooth except for lines of growth which become very much stronger over the anterior end forming irregular rounded lines. Posterior-dorsal margin with a sharp raised edge, margined below by a narrow depression which becomes obsolescent medially.

Remarks.—This species is differentiated from *Eosolen lisbonensis* (Aldrich, 1886) from the Lisbon Formation, by the less angulated anterior end and shorter form, from *Solen pendeltonensis* Barry, 1942 from the Wilcox group, by the strong groove, wider form and strong growth lines, and from *Solena (Eosolen) lisbonensis abruptus* (Dall, 1900) from the Cook Mountain Formation by its more elongate form and rounded anterior end. Palmer and Brann (1965) questionably assign Dall's species to *Eosolen.* The posterior-dorsal angulation can also distinguish *E. shirleyi* from the preceding three species. The Reklaw specimen is attached to a block of matrix so the interior cannot be observed.

Etymology.—Named after my wife Shirley, who discovered the first specimen.

Type information.—Holotype: a right valve, PRI 30301. Type locality: locality 14.

Material examined.—Six specimens, length: 26.2, height: 7.5 mm.

Superfamily **TELLINOIDEA** Blainville, 1814, p. 179

Family **TELLINIDAE** Blainville, 1814, p. 179

Subfamily **TELLININAE** Blainville, 1814, p. 179

Genus **TELLINA** Linnaeus, 1758, p. 674

Type species.—Tellina radiata Linnaeus, 1758, by subsequent designation (Schmidt, 1818, p. 51). Recent in the West Indies.

Diagnosis.—Shell ovate to ovate-trigonal, compressed, usually rostrate. Umbones subcentral or posterior to mid-length. External surface rarely smooth, dominant sculpture usually concentric, commonly suggested by the color pattern and sometimes internal rays. Ligament external, situated in an elongate groove. Two small cardinals in each valve, at least one of them bifid. Lateral teeth always present in one valve, usually strongly developed in the right valve, weaker and sometimes obsolescent in the left. Pallial sinus large, coalescent ventrally with the pallial line, anterior adductor muscle scar of similar size but more elongated than posterior.

Remarks.—The genus ranges from the Upper Cretaceous to Recent. Recent species of the genus are cosmopolitan in distribution, occurring in both polar and tropical waters, and from the high tide level to depths greater than 600 fathoms.

Subgenus **EURYTELLINA Fisher, 1887**, p. 1147

Type species.—Tellina punicea Born, 1778, by monotypy. Recent from East Coast of Central America.

Diagnosis.—Shell elongate-ovate, posterior end not rostrate; umbones very slightly anterior, sculpture of fine concentric lines or threads; two lateral teeth in both valves, left valve laterals not as prominent; right posterior and left anterior cardinal teeth trigonal and bifid; pallial sinus the same in both valves, touching the anterior adductor scar.

Remarks.—The subgenus ranges from the Eocene to Recent, and is restricted to North and South America.

Tellina (Eurytellina?) milamensis, new species

Plate 6, figures 9, 10

Description.—Shell equilateral, height 57% of length, umbones almost central at 53% of length. Beak not incurved, not prominent, lunule not visible, escutcheon small and defined by a sharp concave ridge. Left valve with bifid anterior cardinal tooth parallel to the dorsal-ventral mid-line, and another smaller, thin lamellar posterior cardinal tooth, the dorsal end merging into the anterior margin of the small nymph. Posteriorly to the nymph is a rounded callosity extending externally from the valve margin. Anterior dorsal margin almost straight and parallel to the posterior ventral margin, posteriorly acuminate. Rostral area defined by a weak rounded angulation and a few obscure radial rays. Surface smooth or with concentric undulations which are well-defined behind the rostral angulation and on the extreme anterior dorsal margin. Traces of color banding still preserved, consisting of thin brown streaks originating at the rostral area and increasing in size and prominence towards the anterior dorsal margin.

Remarks.—Without examination of the shell interior this species might be assignable to either *Eurytellina,* Fisher, 1887, or *Moerella,* Fisher, 1887. Both subgenera are reported by Stenzel *et al.* (1937) and Palmer and Brann (1966) from the Texas Claibornian. Keen (1969, p. N615) gives the geologic range of *Eurytellina* as Miocene–Recent, and *Moerella* as Early Eocene–Recent. All available specimens are cemented to blocks of matrix. The hinge description is made possible by the breaking of one specimen free of the matrix, but that was still not enough to determine the subgenus. The shell outline, the medium sized bifid tooth and the obsolete radial sculpture make an assignment to *Eurytellina* more likely. *T. (E.) milamensis* can be distinguished from its closest relative, *Tellina (Eurytellina) mooreana* Gabb, 1860 from the Weches Formation, and Stone City Member of the Cook Mountain Formation by its more trapezoidal shape, the excavated area posterior to the beak, and the obsolete sculpture. The left valve of *Tellina (Eurytellina) papyria* Conrad, 1833b from the Lisbon and McBean formations, another similar species, has not been described but its hinge shows a large bifid anterior cardinal and no posterior cardinal, its place taken by the raised margin of the nymph. All specimens of *T. (E.) milamensis* are very thin, many are even translucent.

Type information.—Holotype: a left valve, PRI 30302; paratype: right valve hinge fragment, PRI 33121. Type locality: locality 20.

Material examined.—Ten specimens the largest: 15.0 mm length, 8.5 mm height, umbones at 53% of length.

Genus **ARCOPAGIA** Brown, 1827, pl. 16, fig. 8

Type species.—Tellina crassa Pennant, 1777, by subsequent designation (Hermannsen, 1846, p. 76). Recent, on the boreal coast of Europe.

Diagnosis.—Shell large or small, orbicular, solid, rounded, moderately convex. Posterior flexure obsolete, beak high. Sculpture concentric, rarely radial, usually smooth or sometimes reduced to incremental lines. Two cardinals in each valve, the right posterior and left anterior bifid, right valve with strong laterals, left valve usually with obsolete laterals. Pallial sinus not close to the anterior adductor scar. The chief feature of this group is the free and ascending sinus.

Remarks.—Afshar (1969) is followed in giving *Arcopagia* generic rank. This genus is known from the Cretaceous to Recent, today primarily in the Indo-Pacific. The type subgenus has a similar pallial sinus in both values and the ventral margin of the pallial sinus entirely free.

Arcopagia (Arcopagia) trumani (Harris)
Plate 6, figures 11–13

Tellina (Arcopagia) trumani Harris, 1897b, p. 73, pl. 12, fig. 15, pl. 14, figs. 10, 10a.

Description.—Shell small, compressed-elliptical; beaks central. Pallial sinus large, margins parallel, extending a distance three-quarters into the shell interior. Left valve cardinal asymmetrically bifid. Right valve with a deep groove dorsal to the anterior lateral tooth.

Remarks.—Eight specimens were obtained that have a very similar outline to *T. (A.) trumani,* a species from the Lower Eocene. The surface is covered with raised concentric fine threads, not noticeably weaker towards the dorsal margin. The outline does not have the weak emargination of *Arcopagia (Arcopagia) trumani australina* (Harris, 1919), a later representative from the Middle Eocene. The two cardinal teeth, only visible in the left valve, are very small and almost fused, the anterior one is bifid. *Tellina tallicheti* Harris, 1895a from the Weches at Smithville, Bastrop County, Texas, is another similar species but its exterior is mostly smooth and has a bifid posterior cardinal. This record extends the occurrence of *T. (A.) trumani* into lowest Claibornian times.

Type information.—Three syntypes: PRI 170, 230, 231. Type locality: Gregg's Landing, Alabama River, Alabama. Range Lower Eocene, Tuscahoma Formation of Alabama, to Middle Eocene, Reklaw Formation of Texas. Figured Reklaw specimens: a right valve, PRI 33076; a left valve fragment, PRI 33122, from locality 20.

Material examined.—Eight specimens. Dimension of the largest: 10.8 mm length, 9.0 mm height, umbones at 55% of length.

Superfamily **ARTICOIDEA** Newton, 1891, p. 295

Family **KELLIELLIDAE** Fisher, 1887, p. 1022

Genus **LUTETIA** Deshayes, 1860, p. 787

Type species.—*Lutetia parisiensis* Deshayes, 1858 (in Atlas of plates), by subsequent designation (Stoliczka, 1871, p. 279). Eocene of the Paris Basin.

Diagnosis.—Shell very small, globose, circular in outline. Umbo almost central, beaks pointed in an anterior direction. Surface smooth or with slight concentric undulations. Interior highly polished, adductor muscle scars small, equal, oval; pallial line simple. Ligament external, on the nymph. Hinge with three teeth in each valve. Right valve with one tooth beneath the lunule and parallel to the margin, a central lower one commonly L-shaped and a posterior one pointing backwards; valve margin grooved. Left valve teeth laminar.

Remarks.—The genus is known from the Eocene to Recent, Europe and North America.

Lutetia cf. **texana** Harris, 1920
Plate 7, figures 7–10

Lutetia texana Harris, 1920, p. 7, pl. 17, figs. 7, 8; Gardner, 1945, p. 99, in part; Brann and Kent, 1960, p. 989.

Description.—Shell very small; ovate to slightly elliptical in outline. Exterior smooth, shining, with weak concentric undulations. Lunule large, well defined by a radiating, impressed line. Ligamental margin deeply channeled. Cardinal area narrow. Right valve with a prominent tooth just posterior to the umbo; left valve with a corresponding deep pit.

Remarks.—The Reklaw specimens differ from *Lutetia texana* s.s. by their smaller size, and in the right valve the central lower tooth is slightly thinner and more elongate. The differences however are not considered significant particularly as all specimens appear to be juveniles. Despite the fact that *Lutetia* has only previously been reported from the Weches Formation at Nacogdoches, Texas, it is in fact well represented throughout the Texas Claibornian.

Type information.—Holotype: a right valve, PRI 33081, 0.5 mm diameter; paratypes: PRI 33082–33084. Type locality: locality 4.

Material examined.—39 specimens, the largest 0.6 mm diameter.

Genus **ALVEINUS** Conrad, 1865b

Type species.—*Alveinus minutus* Conrad, 1865b, p. 138, by monotypy. Eocene, Gosport Sand Formation of Alabama.

Diagnosis.—Shell minute, equivalved, smooth. Right valve with two parallel teeth, resilial pit below the beak, posterior valve margin channeled. Left valve with corresponding resilial pit, a bifid tooth anteriorly and anterior valve margin channeled. Pallial line entire.

Remarks.—Palmer and Brann (1965) only report this genus from the upper Claiborne Gosport Sand Formation of Alabama and the Jackson Group of Louisiana. In the author's experience, however, it occurs abundantly in all Claibornian exposures. The range of the genus is Eocene to Miocene.

Alveinus cf. **minutus** Conrad, 1865b
Plate 7, figures 11–12

Alveinus minutus Conrad, 1865b, p. 138, pl. 10, fig. 2, as *minuta*; 1872, p.53, pl. 1, fig. 6; Meyer, 1885; p. 467; 1886b, p. 84, pl. 1, fig. 19; Dall, 1899, p. 883; 1900, p. 1166; Harris, 1919, p. 110, pl. 37, fig. 15 copy Meyer; 1920, p. 8, pl. 17, figs. 11–15, text-fig. 5; Harris and Palmer, 1946, p. 83, pl. 19, figs. 5, 5a copies Harris, 1920; Brann and Kent, 1960, p. 989; Olsson, 1964, p. 44;

Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, p. 33.
Alveinus parvus Conrad, 1865a, p. 10, as *parva nomen nudum*; 1866a, p. 24 *nomen nudum*; de Gregorio, 1890, p. 210 not *mimatur* as in synonymy, pl. 30, fig. 30, fig. 14 copy Meyer, fig. 14b copy Conrad; Dall, 1903, p. 1166.
Lutetia parva (Conrad). Cossmann, 1893b, p. 13.

Original description.—"Suboval or suborbicular, very inequilateral, convex, smooth and shining; margins rounded. This is a minute shell, much enlarged in the figure, and common in a small quantity of marl which accompanies the specimens. The family to which it should be referred is undetermined. A microscopic channel margins the valves within." (Conrad, 1865b, p. 138).

Remarks.—Only two right valves were obtained of this species. Both have an almost identical outline but are about half the size of typical Gosport Sand specimens. The hinge characters are a little different; the resilial pit is smaller, shifted anteriorly and its place taken up by an elongated and more angular upper tooth. Whether or not this is enough to separate the Reklaw specimens must await the discovery of more material.

Type information.—Three syntypes: ANSP 13221 (Moore, 1962, p. 75). Figured Reklaw specimen: a right valve, PRI 33085, from locality 4.

Material examined.—Two Reklaw specimens, ca. 1.3 mm diameter. Numerous Cook Mountain and Gosport Sand specimens.

Superfamily **VENEROIDEA** Rafinesque, 1815, p. 20

Family **PITARIIDAE** Stewart, 1930, p.232

Subfamily **PITARINAE** Stewart, 1930, p. 232

Genus **PITAR** Römer, 1857, p. 15

Type species.—*Venus tumens* Gmelin, 1791, by monotypy. Recent, west coast of Africa.

Diagnosis.—Shell oval to subtrigonal, moderately to strongly inflated, umbones anterior, beaks prosogyrate. Ornamentation smooth or finely lamellate, comarginal ribs, lunule defined by an incised line, escutcheon long, poorly defined. Right valve with two anterior lateral hinge teeth, and three cardinal teeth; posterior cardinal tooth (3b), elongate, almost horizontal, and bifid. Left valve: 2b triangular, joined to a thin 2a, 3a and 1 separate. Pallial sinus deep, reaching midlength. Valve margins smooth.

Remarks.—The genus ranges from the Paleocene to Recent. At least 33 species are described from the Paleogene of the Gulf and Atlantic Coastal Plains.

Subgenus **CALPITARIA** Jukes-Browne, 1908, p. 155

Type species.—*Callista sulcataria* Deshayes, 1825a, by original designation. Eocene, (lower Lutetian) of the Paris Basin.

Diagnosis.—Differing from *Pitar s.s.* in having a short, wide, rounded pallial sinus.

Remarks.—The subgenus is restricted to the Eocene of the northern hemisphere.

Pitar (Calpitaria) turneri, new species
Plate 7, figures 1–2

Description.—Shell medium in size, height about 89% of length, width (of single valve) about 31% of height, umbones prominent, tip enrolled, and anterior at about 17% of the length. Anterior end quite sharply rostrate, ventrally smoothly curved, the posterior end rounded, straighter dorsally. Escutcheon not observed, lunule large, defined by an inpressed line, about twice as long as high. Juvenile sculpture of somewhat irregular rounded lines. Adult sculpture of prominently wrinkled, close-set lines, sometimes bifurcating, essentially constant in strength over the shell surface except within the lunule where the wrinkled character disappears. No left valves found. Hinge of right valve with a strongly bifid cardinal 3b tooth, a strong triangular cardinal 1 tooth and a prominent thin projecting cardinal 3a tooth, both 3a and 1 projecting more than the other teeth. Two moderately sized pits above and below the anterior end of tooth 3a, anterior lateral very poorly defined, right posterio-dorsal valve margin grooved. Pallial sinus fairly short and stubby, the end rounded, anterior muscle-scar gourd-shaped with the neck pointing towards the pallial line.

Remarks.—At least three species of *Calpitaria* are found in the Reklaw but this is the only species that is well enough preserved for description. The two projecting cardinal teeth, 3a and 1, are a feature also seen in the Weches species *Pitar (Calpitaria) texacola* (Harris, 1919). That latter species, although shorter than *P. (C.) turneri* does show some irregularity in the undulations on the rostral area. Another similar species is *Pitar (Calpitaria) petropolitanus* Stenzel and Krause, 1957, which is restricted to the Cook Mountain Formation, that species has a sculpture of close-set, flat-topped comarginal ribs sometimes restricted to the shell margins, deep sockets anterior to teeth 3a and 3a and tooth 1 almost equal in size. One could surmise *P. (C.) turneri* is the ancestor of *P. (C.) texacola* but this appears unlikely as the author has an undescribed, very elongate Weches species from Burleson Bluff with the same unique external sculpture as *P. (C.) turneri*.

Etymology.—Honoring previous Reklaw worker F. E. Turner.

Type information.—Holotype: right valve, PRI 33086; paratype: a juvenile right valve, PRI 33087. Type locality: locality 4.

Material examined.—Two specimens, one juvenile, both right valves. The adult 30.2 mm in length, height 27.0 mm, width 8.3 mm, umbones at 17% of length.

Pitar (Calpitaria?) sp.

Plate 7, figs. 3–6

Remarks.—Numerous small juveniles, or "spat", were obtained of a species of *Pitar.* No intermediate sized specimens were found between the adult size of *Pitar (Calpitaria) turneri* n. sp. and these juvenile ones, so an assignment to that latter species cannot be made with confidence. However, the hinge features of both species show many similarities, and the assignment to the genus is assured after comparison with growth series of other *Pitar* species. The shell outline alon can distinguish these from other small Reklaw bivalve species.

Material examined.—21 specimens, the largest 1.36 mm. Figured specimens, a right valve: PRI 33132, a left valve: PRI 33133, from locality 4.

Subgenus **KATHERINELLA** Tegland, 1929, p. 280

Type species.—Callocallista arnoldi Weaver, 1916, by original designation. Oligocene of western Washington.

Diagnosis.—Shell thin, ovate, orbicular or subquadrate in outline. Beaks slightly elevated, prosogyrate, posterior dorsal margin almost straight. Sculpture with concentric growth lines and close-set concentric threads rounded on top, obsolescent at the escutcheon angulation. Lunule outlined by an impressed line and centrally swollen. Hinge like *Pitar* but left valve with an elongate anterior lateral tooth (AII) far forward and near the upper margin of the hinge plate.

Remarks.—Oligocene, western North America, Eocene of Gulf Coastal Plain. Recent.

Pitar (Katherinella?) sp. A

Plate 7, figure 13

Description.—Shell thin, orbicular with fairly pronounced prosogyrate beak. Margin anteriorly and ventrally evenly rounded, posterior-dorsally straighter. Sculpture with very fine and even concentric rounded threads, about 20 per mm, many of which coalesce as they approach the margins. Lunule very indistinct, defined by a colored line.

Remarks.—The only specimen is cemented to a block of matrix so that the hinge characters cannot be observed. Its external features closely resemble the Stone City Member species *Pitar (Katherinella?) texitrina* Stenzel and Krause, 1957. Another much larger species with a similar outline is *Pitar (Katherinella?) trigoniata bastropensis* (Harris, 1919); Palmer and Brann (1966), list this species from Devil's Eye, a locality believed assignable to the Queen City Formation or upper Reklaw Formation. The much finer concentric threads and indistinct lunule can distinguish this species from other Gulf coast *Katherinella* species.

Material examined.—One specimen a left valve, length: 12.3 mm, height: 12.3 mm Figured Reklaw specimen from locality 20, PRI 33088.

Pitar (Katherinella?) sp. B

Plate 7, figure 14

Remarks.—Two individuals, possibly from the same lot noted by Stenzel et al. (1957, p. 137), from Devil's Eye were examined and found to have external sculpture similar to *Pitar (Katherinella?) trigoniata* var. *bastropensis* (Harris, 1919). In neither specimen is the hinge available for study so a definite generic determination cannot be made. It is easily distinguished from species A by the coarser ornamentation and trigonal outline.

Material examined.—Figured specimen: TMM 84819, length 22.0 mm. Figured Reklaw specimen from locality 11.

Order **MYOIDA** Stoliczka, 1870, p. xv

Suborder **MYINA** Stoliczka, 1870, p. xv

Superfamily **MYOIDEA** Lamarck, 1809, p. 319

Family **CORBULIDAE** Lamarck, 1818, p. 536

Subfamily **CORBULINAE** Lamarck, 1818, p. 56

Genus **CARYOCORBULA** Gardner, 1926, p. 46

Type species.—Corbula alabamensis I. Lea, 1883, by original designation. Claibornian Eocene of the Gulf and Atlantic coastal plains.

Diagnosis.—Shell small or of moderate size, acutely keeled posteriorly; slightly inequivalve; right valve a little larger and higher relatively than the left; both valves concentrically rugose, the sculpture of the right valve in some species stronger and more regular than the left; a microscopically fine radial lineation developed in some of the larger species, particularly on the posterior keel; ligament, dental, muscle, and sinus characters similar to that of *Corbula* s.s.

Remarks.—Recent representatives are suspension feeders, worldwide in distribution but more abundant in warmer waters; commonly found below the tidal level; the animals are burrowers. The genus is known from the Upper Cretaceous to Recent.

Caryocorbula marquezensis, new species
Plate 7, figures 15–18

Description.—Shell small, solid and stongly inflated. The sculpture consists of concentric ribs, that are flattened towards the margins and sharply ridged towards the umbo; umbones central at about 34% of length, umbonal area set off by a sharp ridge. Right valve cardinal tooth is flattened parallel to the hinge line and curves towards the umbones. Valve margins on both sides of the rostrum concave. Pallial sinus broad and moderately deep. Left valve with two small teeth on the margin next to the resilium pit. Posterior extremity concave.

Remarks.—The closest described form is *Caryocorbula deusseni* (Gardner, 1924) which ranges from the Weches Formation to the Stone City Member. *C. deusseni* is larger, more elongate, has regularly rounded ribs that are placed irregularly on the surface, has a conical right valve cardinal tooth, and a rostrum pinched inwards at the dorsal margin.

Etymology.—The specific name refers to the Marquez member.

Type information.—Holotype: right valve, PRI 30300; paratypes: right valve and left valve, PRI 30303,30304. Type locality: locality 20.

Material examined.—21 specimens. Dimensions: largest right valve, 6.1 mm length, 3.8 mm height, 1.7 mm width. Largest left valve, 6.1 mm length, 4.3 mm height, 1.9 mm width. Mean ratios: right valves: height/length .75, width/height .45, left valves: height/length .72, width/height .43.

Genus **NOTOCORBULA** Iredale, 1930, pp. 404–405

Type species.—Notocorbula vicaria Iredale, 1930, by original designation. Recent off the coast of New South Wales, Australia.

Diagnosis.—Right valve larger, margins grooved for the insertion of the left valve. Umbones inflated, relatively low, capped by nepionic valves, both valves rostrate posteriorly into a snout. Umbonal keel strong, extending to the posterior-ventral margin with another weaker keel extending to the dorsal side of the posterior margin; area between the keels concave. Right valve with strong concentric ribbing, the left valve with weaker ribbing. Right valve with a prominently "keeled" anterior cardinal, a small resilium pit; left valve with a bipartite chondrophore. Adductor scars large and prominent; pallial sinus small, almost vertical.

Remarks.—The genus is known only from the Eocene and Recent.

Notocorbula marquezensis, new species
Plate 8, figures 1–5

Description.—Shell small, heavy, strongly inflated. Posterior end of right valve moderately rostrate and obliquely truncate, the posterior dorsal margin curving back sharply from the rostrum. Rostrum extended into a prominent rectangular snout. Cardinal tooth triangular in cross section, rounded below, sharp above and upturned towards the umbones. Nepionic portion of valve smooth or almost so, remainder with coarse flattened folds and occasional smaller intermediate ones. Left valve with much more subdued sculpture and a prominent resting stage between the nepionic and adult areas of the shell forming a distinct cap. Posterior muscle scar thickened prominently and elevated into the interior.

Remarks.—The only other species of *Notocorbula* described from the Gulf Coastal Plain is *Notocorbula texana* (Gabb, 1860) from the Stone City Member of Texas. The Stone City specimens have more regularly rounded primary ribs with few intermediate secondary ones and a more cylindrical cardinal tooth. The most noticeable features differentiating the Reklaw specimens from *N. texana* are the rounder outline, the pinched character of the ribs as they cross over the rostral ridge, giving the appearance of a weak, rounded, radial rib, and the greater attendant change of angle there. On the left valve the elevated muscle scar situated on a platform can immediately distinguish it from the Stone City species.

Type information.—Holotype: right valve, PRI 30305; paratypes: one right valve, two left valves and one double valve, PRI 30306–30308. Type locality: locality 20.

Material examined.—400+ specimens: right valves: the largest, 7.5 mm length, 5.8 mm height, 3.1 mm width. Left valves: the largest, 5.8 mm length, 4.6 mm height, 2.4 mm width. Double valves: the largest 6.1 mm length, 5.1 mm height, 4.2 mm width. Mean ratios: right valves: height/length .81, width/height .55; left valves: height/length .83, width/height .53; double valves: height/length .81, width/height .91.

Superfamily **HIATELLOIDEA** Gray, 1824, p. 60

Family **HIATELLIDAE** Gray, 1824, p. 60

Genus **PANOPEA** Menard, 1807, p. 135

Type species.—Mya glycymeris Born, 1778 (= *Panopea faujas* Menard, 1807), by subsequent designation (Schmidt, 1818, p. 177). Recent in the Mediterranean.

Diagnosis.—Shell usually large, inflated, equivalved, beaks subcentral, usually gaping at both ends. Surface smooth or concentrically furrowed. Ligamental nymph large and high. A single prominent conical tooth in each valve. Pallial sinus wide and deep.

Remarks.—The genus is known from the Upper Cretaceous to Recent, where it usually occurs in cooler waters.

Panopea? sp.

Plate 8, figure 6

Remarks.—Four specimens comprising at least two species of *Panopea* sp. have been found in the Reklaw deposits. In one of them the shell is very thin and quadrate in outline, the other is more elongate and rounded. As the hinge is not visible they could not be subgenerically differentiated. The commonest form is the second mentioned and is figured.

Figured specimen.—A right valve, from location 7, PRI 30481.

Suborder **PHOLADINA** H. and A. Adams, 1856, p. 323

Superfamily **PHOLADOIDEA** Lamarck, 1809, p. 319

Family **TEREDINIDAE** Rafinesque, 1815, p. 148

Subfamily **BANKININAE** Turner, 1966, p. 57

Genus **BANKIA** Gray, 1842, p. 76

Type species.—*Teredo bipalmulata* Lamarck, 1801, by subsequent designation (Gray, 1847a, p. 188). Recent in the Indo-Pacific.

Diagnosis.—"Pallets greatly elongate, blade composed of numerous cone like elements on a central stalk, cones separate and easily removed from the stalk, particularly in dried specimens. Cones with calcareous base covered with periostracum which extends as a border. The width and ornamentation of the periostracal border varies greatly; it may be smooth, coarsely to finely serrated, or produced laterally as awns. Siphons fairly long and serrated. Young not retained with the parent." (Turner, 1966, p. 80).

Remarks.—Turner (1966, p. 61) cites the results of several studies demonstrating the difficulty of using shell characters to identify species of Teredinidae, concluding it is often not possible to determine the genus without knowledge of the nature of the pallets. The genus is known from the Paleocene to Recent.

Subgenus **LYRODOBANKIA** Moll, 1941, p. 200

Type species.—*Nausitora kamiyai* Roch, 1931, by subsequent designation (Turner, 1966, p. 108). Recent, temperate and tropical seas.

Diagnosis.—Pallet margin smooth, equal width on both inner and outer faces, produced laterally into short blunt points. Embryonic cones closely packed and covered by periostracal cap.

Remarks.—Prior to this report the genus was only known from the Recent.

Bankia (Lyrodobankia) petalus, new species

Plate 8 figures 7–10

Description.—Shell gently rounded from the anterior-dorsal side to a more sharply rounded ridge parallel to the posterior slope. The posterior slope is broad and rectangular, the lines of growth initially parallel to the shell's dorso-ventral axis, swinging round as they meet the main body of the shell at right angles and then swinging back again to continue obliquely along the disc as low irregular undulations. Umbonal-ventral sulcus with exceedingly fine radial ridges which are themselves crossed by microscopic impressed striae forming a minute lattice pattern. Anterior slope with flat-topped denticulate ridges, spaced wider medially than dorsally or ventrally and bounded posteriorly by a thickened ridge. Cardinal tooth tubular, extending almost the entire interior length of the shell in a shallow arc. Pallets smooth, distal cross-section compressed-rhombohedral, one side smoothly rounded, the other more pointed due to a slight medial carina. On the carinate side, the pallets are laterally produced to a rounded petal-like outline which on the other side converges as a low V, the apex near the expansion point of the tube. Distance between successive pallets about the same as the maximum pallet diameter.

Remarks.—Specimens of free valves are rare in early Tertiary deposits, this set and another two single valves from the Cook Mountain Formation collected by the author being the only ones known from the Eocene of the Gulf or Atlantic Coastal plain. Pallets are required to distinguish to generic or subgeneric level and they have only been found in a few instances. Turner (1966, pp. 14–17) lists two occurrences from North America, one from the Paleocene of North Dakota and the other from the Oligocene of Washington; several more have been found in western Europe. Both primary Reklaw localities have yielded tubes with pallets, in each case the tubes with pallets were found in immediate proximity to the fossilized wood specimen, but not within it. The tubes have a smooth exterior, are crowded closely together, the whole mass very convoluted. The interior of the tubes was filled with a soft, microscopically fibrous material, with the valves at one end and the pallets close to the valves, a condition which according to Turner often happens during death or disturbance of the animal. Even more unusual was the discovery of a very thin sheaf covering the pallets; this was broken in the preparation but can still be seen in places, and is surmised to be the remnants of the periostracum. The carbonized remains of one animal was even found in the interior of one double valve. According to Turner (1966, p. 32) the young are not retained with the parent; this was perhaps not the case in Eocene times as excavation of one tube revealed two minute valves between the pallets and the shell. All previous species of *Bankia* from the Gulf and Atlantic coastal plain are all described from the tubes, which are notoriously variable in character. Three species of *Bankia,* whose preservation warrants a comparison are *Bankia maverickensis* (Gardner, 1923), from the Kincaid Formation, *Bankia emacerata* (Whitfield, 1885), from the Shark River Formation, and *Bankia ringens* (Aldrich, 1921), from the Wills Points Formation. *B. maverickensis* is described as occurring in fossilized wood, and has a closely wrinkled surface; *B. emacerata* is also described from fossilized wood and has tubes that taper rapidly towards the apex; *B. ringens* has tubes with raised thickened rings, set virtually at right angles to the axis. The remainder of the *Bankia* species are described from such poor material as to make a comparison difficult.

Etymology.—Referring to the resemblance of the margin of the pallets to petals.

Type information.—Holotype: a tube with pallets, PRI 33125; paratypes: PRI 33090–33095. Type locality: locality 7.

Material examined.—Seven specimens of valves, two partial pallet sets, three separated pallets, and numerous tubes in fossilized wood. Largest free valve pair: diameter 2.5 mm, largest free pallet: 1.52 mm length, 1.14 mm width.

Subclass **ANOMALODESMATA** Dall, 1889b, p. 64

Order **PHOLADOMYOIDA** Newell 1965, p. 21

Superfamily **PHOLADOMYOIDEA** Gray, 1847, p. 187

Family **PHOLADOMYIDAE** Gray, 1847, p. 187

Genus **PHOLADOMYA** G. B. Sowerby, 1823a[3]

Type species.—*Pholadomya candida* G. B. Sowerby, 1823a, by subsequent designation (Gray, 1847, p. 194). Recent, southeastern West Indies.

Diagnosis.—Shell medium sized to large, thin, nacreous. Outline ventricose, transversely ovate-trigonal to subquadrate, gaping posteriorly. Umbones anterior, prominent, escutcheon faint, often defined by flattening of the shell or disappearance of the sculpture. Surface microscopically pustulose, ornament usually strong, both radially and concentrically, at the intersections more or less noded. Hinge edentulous, ligament external, pallial sinus broad and moderately deep.

Remarks.—The genus was most diverse in the late Mesozoic and has declined steadily since. Six species are known from the Paleogene of the Gulf Coast, two in the Recent fauna.

Pholadomya cf. **leonensis**, Stenzel and Twining, 1957
Plate 8, figures 11–12

Pholadomya leonensis Stenzel and Twining, 1957 *in* Stenzel, Krause, and Twining, 1957, p. 164, pl. 18, fig. 13; pl. 19, figs. 4, 5.

Remarks.—These specimens are preserved as clay molds with fragments of attached shell, one partial valve with exterior cemented to matrix was also found. Due to the distortion no meaningful comparison can be made with the outline of other species. The few fragments of shell remaining show a microscopic pustulose surface similar to that seen in *Pholadomya leonensis* Stenzel and Twining, 1957 from the Weches Formation. Another feature seen in *P. leonensis* is the almost complete absence of radial folds except close to the umbo; the valve fragment shows this feature.

Material examined.—Four molds and one incomplete valve. The largest specimen: 24 mm length, 14 mm maximum height, 18 mm double valve thickness.

Type information.—Holotype: TBEG 20550. Type locality: North ditch of old abandoned Concord-Centerville county road, 0.6 mile southeast of dismantled Robbins depot, Texas Bureau of Economic Geology location, 145-T-1. Figured Reklaw specimen: PRI 33096, from locality 4.

Superfamily **PANDOROIDEA** Rafinesque, 1815, p. 20

Family **PERIPLOMATIDAE** Dall, 1895, p. 528

Genus **COCHLODESMA** Couthouy, 1839, p. 170

Type species.—*Anatina leana* Conrad, 1831, by subsequent designation (Hermannsen, 1847, p. 266). Recent, northeastern coast of North America.

Diagnosis.—Lenticular, subequilateral; lithodesma present, chondrophore buttressed. Surface smooth or minutely scabrous, with a fine epidermis.

Remarks.—An uncommon genus, found in boreal to temperate waters at moderate depths. The genus is known from the Miocene to Recent.

Subgenus **COCHLODESMA** Couthouy, 1839, p. 170

Diagnosis.—"Slightly inflated, surface not granulose; lithodesma cartilaginous" (Keen *in* Moore, p. N850).

Cochlodesma (Cochlodesma) ovalis, new species
Plate 8, figure 15

Description.—Shell, small, very thin, ovate, anteriorly larger. Surface smooth or irregularly concentrically plicate, overridden with lines of growth, medially obsolescent, stronger on both ends of the shell. Interior nacreous, pallial sinus and muscle scars not visible, chondrophore thin and spoon-shaped.

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[3] On unnumbered page 228.

Remarks.—To date *Cochlodesma* has not been recognised as a fossil earlier than the Miocene. Gardner (1943) lists just one species, *Cochlodesma antiqua* (Conrad, 1834) from the Yorktown Formation of North Carolina. As fossils, representatives of the genus *Cochlodesma* may be distinguished from those of the closely similar genus *Periploma* by the combination of the smooth rather than granular surface and the more regularly ovate outline. One double valve, but flattened specimen shows the remnants of the lithodesma in the chondrophore cup. The rounded outline of *C. ovalis* is closer to that of the the type of *Cochlodesma leanum* than the Miocene species *C. antiqua.* Both periplomatid genera *Cochlodesma* and *Periploma* are commonly found in the Weches and Cook Mountain formations in east Texas although usually in a fragmentary condition.

Etymology.—Referring to the ovate outline.

Material examined.—11 specimens, the largest complete: 13.5 mm length, 8.7 mm height. The length of one fragmentary specimen is estimated at 76 mm.

Type information.—Holotype: a right valve, PRI 33097; paratype: PRI 33098. Type locality: locality 4.

Superfamily **POROMYOIDEA** Dall, 1886, p. 292

Family **CUSPIDARIIDAE** Dall, 1886, p. 292

Genus **CARDIOMYA** A. Adams, 1864, p. 330

Type species.—Cardiomya gouldiana Hinds, 1843, by monotypy. Recent, Sea of Japan.

Diagnosis.—Shell radially ribbed on the main part of the shell, rostrum smooth; similar to *Cuspidaria* but with more prominent fossette, thinner septum and prominent radial sculpturing. Right valve with a prominent posterior lateral tooth.

Remarks.—Unlike most Cuspidariidae, Recent species of this genus prefer shallow water. The genus is known from the Upper Cretaceous to Recent.

Cardiomya fredsmithi, new species

Plate 8, figures 16–17

Description.—Shell very small, ovate triangular, highly inflated, umbones central and enrolled. Sculpture of 16 strong, slightly irregular placed ribs, small and close-set anteriorly and becoming larger and further apart towards the posterior margin. Umbonal slope weakly defined and with three larger ribs. The ribs are crossed by regular concentric rounded lines, the interstices wider than the lines and the intersections of the lines with the ribs tending to become nodular near the ventral margin. Hinge line short and straight, one upturned cardinal tooth.

Remarks.—At first sight this species is reminiscent of *Verticordia eocenensis* Langdon, 1886 from the Gosport Sand Formation, but genus *Verticordia* all have a nacreous interior. *C. fredsmithi* belongs to the small group of *Cardiomya* spp. with a very truncated rostrum, of which *Cardiomya attenuata* (Aldrich, 1886), from the Lisbon Formation at Claiborne Bluff, Monroe County, Alabama, *Cardiomya (Cardiomya)* sp. Perrilliat (1984, p. 22, pl. 20) from the Miocene of Mexico, and *Cardiomya curta* Jeffreys, 1881, Recent of the Eastern Pacific are representatives. The closest species is perhaps *C. attenuata* which is also covered with fine concentric lines. The Reklaw species is distinguished from the others primarily by its almost obsolete rostrum and the presence of radial ribs over the entire surface.

Etymology.—The species is named in honor of Professor Fred Smith, a distinguished worker in Texas geology, and whose publication (Smith, 1962) was instrumental in causing the author to examine Joe Taylor Branch.

Type information.—Holotype: a left valve, PRI 30482. Type locality: locality 20.

Material examined.—Four specimens and two large fragments. The largest 3.0 mm length, 3.0 mm height, 1.3 mm width, umbones central.

Cardiomya sp.

Plate 8, figure 18

Remarks.—A second species is represented here by three incomplete specimens. The best one is an impression in matrix with some fragments of attached shell material. The species is very thin-shelled, surface smooth with 13 sharp radial ribs, closely spaced anteriorly, widest just prior to the smooth rostrum. The species is very close to an undescribed species from the Cook Mountain Formation where it is reasonably common. Larger specimens show an unequal development of ribs; a feature also seen on large Cook Mountain specimens.

Material examined.—Three fragments. The one complete impression: 5.6 mm in length, 2.0 mm height.

Figured specimen: A right valve, from location 7, PRI 30538.

Family **VERTICORDIIDAE** Stoliczka, 1871, p. 224

Genus **VERTICORDIA** J. de C. Sowerby, 1844b, pl. 639

Type species.—Hippagus cardiiformis J. de C. Sowerby, 1844b, by monotypy. Coralline Crag (Plio/Pleistocene) of England.

Diagnosis.—Shell small, inflated, with nacreous interior and usually ornamented with strong curved ribs. Ligament internal with large lithodesma.

Remarks.—The genus lives primarily in deep water. Palmer and Brann (1965), list 11 species from the Paleogene of the southern and eastern United States. The genus is known from the Paleocene to Recent.

Subgenus **TRIGONULINA** d'Orbigny, 1846, p. 291

Type species.—*Trigonulina ornata* d'Orbigny, 1846, by monotypy. Recent in the Caribbean and eastern Pacific.

Diagnosis.—"Shell laterally compressed with prominent radial ribbing, lithodesma long and flat. Right valve with strong lateral tooth, left valve edentulous. Interior brilliantly nacreous." (Bernard, 1974, p. 115).

Remarks.—The species of this subgenus live in shallower water than *Verticordia* s.s. Intensive collecting in the Claibornian suggests *Trigonulina* is much rarer than *Verticordia* s.s.

Verticordia (Trigonulina) cf. **satex** Gardner, 1927

Plate 8, figures 13–14

Verticordia satex Gardner, 1927, p. 367, figs. 22, 23.

Verticordia (Trigonulina) satex Gardner, Stenzel, Krause, and Twining, 1957, p. 178.

Original description.—"Shell highly nacreous, small, compressed, subtrigonal in outline, inequilateral. Umbones sub-central, incurved, strongly prosogyrate. Margin directly in front of the umbones deeply excavated by the false lunule. Escutcheon absent. Anterior extremity strongly arcuate, posterior dorsal and lateral margins forming a parabolic curve from the umbones to the arcuate base. Outer surface heavily corded with 14 subequal, abruptly elevated ribs radiating from the umbones in gentle curves, convex posteriorly, more widely spaced medially but with no sharp breaks in the spacing; interradials deeply concave and wider than the radials; entire surface microgranular; outer margins sharply dentate. Ligament opisthodetic, deeply inset, continuing to the apices of the umbones. A single, rather stout, sub-umbonal cardinal developed in the right valve, received in the left valve between the dorsal margin and the thickened inner margin of the lunule which functions as a denticle; posterior margin of right valve grooved to receive the bevelled margin of the left. Anterior muscle scar small, elongate, quite deeply sunken, its dorsal extremity beneath the ventral margin of the false lunule, posterior muscle scar obscure, pallial line remote from the margin, distinctly impressed. Dimensions: Altitude, 3.0 millimeters; latitude, 3.0 millimeters; semi-diameter, 0.7 millimeter." (Gardner, 1927, p. 367).

Remarks.—The Reklaw specimens have one or two fewer ribs than Gardner described, are about half the size and are not so trigonal in outline. Because the valves may be juveniles and a little worn it seems best not to describe them as new here. Two right valves were obtained. The only other known Paleogene representative of *Trigonulina, Verticordia (Trigonulina) sotoensis* Aldrich, 1903b, from the Cook Mountain Formation of Mississippi, is differentiated by the unequal spacing of the ribs.

Material examined.—Two specimens, the largest, 1.65 mm length.

Type information.—Holotype: USNM 369240. Type locality: Stone City Bluff, Burleson County, Texas. Figured Reklaw specimen, a right valve: PRI 33099, from locality 4.

Class **SCAPHOPODA** Bronn, 1862, p. 523

Order **DENTALIIDA** da Costa, 1776, p. 152

Family **GADILINIDAE** Chistikov, 1975

Genus **EPISIPHON** Pilsbry and Sharp, 1897, p. 127

Type species.—*Dentalium sowerbyi* Guilding, 1834, by subsequent designation (Suter, 1913, p. 821). Recent off the coast of the Southeastern United States and the West Indies.

Description.—Shell very small, very slender, needle-like, circular, moderately curved, surface smooth except for growth rings that are most conspicuous on the posterior part of the shell; apex having a short projecting tube or a wide narrow U-shaped lateral notch.

Remarks.—Living species are mainly inhabitants of deep water. The genus ranges from the Lower Jurassic to Recent.

Episiphon gracilis, new species

Plate 9, figure 7–8

Description.—Shell small, smooth, glassy, gently and regularly curved. Apertural cross-section rounded-triangular with the apex ventral; the sides of the triangle between 55–60°, apical end ovate. Orifice close to the ventral face, elliptical in outline, the major axis vertical, usually becoming circular at the apical end.

Remarks.—This species is similar to *Episiphon acicula* (Hodgkinson, 1974) from the Wheelock Member of the Cook Mountain Formation, but can be distinguished by the larger ventral angle of the triangular cross-section, the relatively thicker shell anteriorly and the more pronounced triangular outline. All specimens appear to be broken, even those which can be observed in situ within the matrix. Sediment compaction does not seem to be the cause, as that results in longitudinal fractures in most cases while the observed fractures occur in a plane at right angles to the shell axis. The vast majority of breakages have occurred at the anterior end where the shell thickness decreases smoothly to less than .025 mm. It appears the animal must have added new shell material as a sharp rim, thickening the shell wall some distance behind the aperture. The largest specimen is 14 mm although many specimens must have been double that size. Numerous specimens from the type locality exhibit surface markings which are assumed to be the remains of the original color pattern; these are usually evenly spaced concentric rings but may also be longitudinal lines rather like an effaced, ribbed *Dentalium*, one specimen showing both concentric and longitudinal markings.

Etymology.—The specific name *gracilis* (Latin; thin, slender), refers to that characteristic of the species.

Type information.—Holotype: PRI 30310; paratypes: PRI 30311, 30312. Type locality: locality 4.

Material examined.—More than 150 specimens, the largest: 13.9 mm length, 1.4 mm maximum diameter.

Family **DENTALIDAE** Gray, 1847, p. 158

Genus **DENTALIUM** Linnaeus, 1758, p. 785

Type species.—Dentalium elephantium Linnaeus, 1758, by subsequent designation (Montfort, 1810, p. 23). Recent off Amboyna and the Philippine Islands.

Description.—Shell an enlarging curved tube; sculpture of longitudinal ribs at the posterior end that commonly extend the entire length of the shell. Apical, or posterior opening usually with a slit or notch; opening circular or oblique, sometimes modified by the longitudinal ribs.

Remarks.—The Recent animals are cosmopolitan in distribution, and feed on detritus with the apical end below the surface of the sea bottom. The genus is known from the Middle Triassic to Recent.

Subgenus **ANTALIS** H. and A. Adams, 1854, p. 457

Type species.—Dentalium antalis Linnaeus, 1758, by subsequent designation (Pilsbry and Sharp, 1897, p. 37). Recent off the Atlantic coast of Europe.

Original diagnosis.—"Shell small to medium-sized, circular or polygonal in section, less strongly ribbed than *Dentalium* s.s., longitudinal riblets commonly lacking in senescent stages, but present on apical portion of tube in juvenile stages; apical orifice generally with a V-shaped notch on or near the concave side and generally bears a solid plug with central pipe or orifice, rarely simple." (Emerson, 1962, p. 470)

Remarks.—The subgenus is known from the Pliocene to Recent.

Dentalium (Antalis) palmerae, new species
Plate 9, figure 2

Dentalium sp., Palmer, 1937, p. 18, pl. 1, fig. 11; Brann and Kent, 1960 p. 321; Palmer and Brann, 1965 p. 371.

Description.—The shell with ten or 12 sharp longitudinal ribs at the apex. Angle at apical notch about 80°. Single intermediate ribs develop, not always midway between the primary ribs, and rapidly approach the the primary ribs in size. Larger specimens may show up to four intermediate ribs. Primary ribs always define the vertices of a polygonal section. The entire pattern becomes obsolete and smooth with increasing age.

Remarks.—As is the case with *Dentalium (Antalis) thaloides* Conrad, 1833a, from the Gosport Sand Formation, the shell is much thicker posteriorly, the thicker portions surrounding an inner circular section. Palmer (1937, p. 18), described specimens she attributed to *Dentalium* sp. from the Cook Mountain Formation of Louisiana that appear to belong to the same species. The species also occurs in the Weches Formation at Smithville, Bastrop County, Texas.

Etymology.—This species is named after Dr. K. V. W. Palmer who first noted it.

Type information.—Holotype: PRI 30313, from locality 4.

Material examined.—150 + specimens or fragments, longest specimen: 23.4 mm length, 2.1 mm maximum diameter, largest diameter fragment: 2.4 mm.

Order **GADILIDA** Starobogatov, 1974, p. 13

Family **GADILIDAE** Stoliczka, 1868, p. 440

Subfamily **GADILINAE** Steiner, 1992, p. 398

Genus **CADULUS** Philippi, 1844a, p. 209

Type species.—Dentalium ovulum Philippi, 1844a, by monotypy. Miocene to Recent in Italy.

Diagnosis.—Shell small to medium in size with circular cross section, more or less arcuate with maximum inflation between the maximum diameter and the anterior end; aperture usually constricted. Surface smooth, vitreous or transparent, with minute longitudinal striae or annular rings. Apical orifice with two to four notches.

Remarks.—Their distribution is Cretaceous to Recent with more than 100 species known today.

Cadulus (?) bisissura, new species
Plate 9, figure 3–5

Description.—Shell small, smooth or glassy. Shell arcuate with maximum inflation at about 60% of length, profile tapering to a small circular apical end which is characterized by a shallow V-shaped notch on the ventral side and a rounded notch on the dorsal side. Apertural shape a flattened ellipse with the major axis dorsal-ventral; major/minor axis ratio about 1.3.

Remarks.—The only perfect specimen is now unfortunately broken but still shows the apertural characteristics. The shell profile and aperture shape place this species close to *Cadulus (Gadila) erleneae* Hodgkinson, 1974, from the Wheelock Member of the Cook Mountain Formation. The apical notches and position of maximum inflation can differentiate the two species. The shape of the aperture can distinguish both *Cadulus bisissura* and *C. (G.) erleneae* from other Tertiary Gulf coast species. The two shallow apical notches do not correspond satisfactorily to any of the subgenera discussed by Emerson (1962). Subgenus *Platyschides* Henderson, 1920, is a similar taxon possessing similar very shallow notches.

Etymology.—From the Latin for two-notched.

Type information.—Holotype: PRI 30314, 3 mm. length; paratype: PRI 30315. Type locality: locality 4.

Material examined.—Ten specimens, the largest: 3.4 mm length, 0.66 mm maximum diameter.

Cadulus spp.

Remarks.—Broken fragments indicate at least three other *Cadulus* species occurring in the Reklaw, one species highly inflated and similar to *Cadulus (Gadila) ouachitensis* Palmer, 1937, another with a very rapidly contracted apertural end similar to *Cadulus ("Dischides") abruptus* Meyer and Aldrich, 1886, and the third, figured in plate 9, figure 6, from locality (PRI 33121), with affinities to *Cadulus (Polyschides) subcoarcuatus* (Gabb, 1860), cf. pl. 9, fig. 6. More material needs to be found for further separation.

Class **GASTROPODA** Cuvier, 1797, p. 378

Subclass **PROSOBRANCHIA** Edwards, 1848, p. 191

Order **ARCHEOGASTROPODA** Thiele, 1925, p. 74

Suborder **NERITIMORPHA** Golikov and Starobogatov, 1975, p 209

Superfamily **NERITOIDEA** Rafinesque, 1815, p. 144

Family **NERITIDAE** Rafinesque, 1815, p. 144

Genus **THEODOXUS** Montfort, 1810, p. 351

Type species.—*Nerita fluviatilis* Linnaeus, 1758, by original designation. Recent in the Eastern Atlantic Ocean.

Original Diagnosis.—"Coquille libre, univalve, à spire regulière, écrasée; point d'ombilic; bouche entière, arrondie, évasée, perpendiculaire à l'horizon; lèvre extérieure trenchant; nulle dent à cette lèvre ni à la collumella." (*Translation.*—Shell free, univalve; the spire regular, squat, apex depressed; aperture entire, circular, flaring, perpendicular; exterior rim sharp; no tooth on the rim of the columella.).

Revised Diagnosis.—Shell small or very small, ovate to hemispherical, spire moderately high, rarely squat. Outer lip sometimes weakly flaring, not toothed; septum smooth, columella edge smooth or finely toothed. Operculum smooth, apophysis weakly formed.

Remarks.—*Theodoxus*, in common with other members of the Neritidae often have strongly marked color patterns, and according to Russell (1941, p. 355) the presence of color *per se* is of little taxonomic value although the color pattern often is. Modern representatives of the genus are herbivorous and usually prefer estuarine to freshwater conditions. Prior to this occurrence *Theodoxus* has not been known earlier than the Oligocene. One of the earliest representatives is *Theodoxus apertus* (J. de C. Sowerby, 1823b) from the Oligocene Headon Beds, Isle of Wight in England. The genus is particularly well represented from the Miocene to Recent in central Europe and the Middle East.

Theodoxus domicilium, new species
Plate 9, figures 23–24

Description.—Shell small and globose. Protoconch not visible, being covered by a broad flat callus pad, at the bottom of a shallow cylindrical depression. The depression is formed by the side of the whorl initially rising above the pad and then descending again on the final whorl; sides straight and the rim sharp. Suture impressed and bordered below by a small depression, giving the whorl a slightly shouldered profile. Surface glossy with fine curved lines of growth and retaining a color pattern of irregular wavy lines curving back from the sutural region, forward again past the mid point of the whorl and then showing one or two smaller undulations below. Aperture ovate, outer lip sharp, columella septum thin, straight and smooth. Callus broad and thin.

Remarks.—The absence of teeth or an apophysis preclude placing this specimen in the *Neritina* group, and although the remaining characters place it in genus *Theodoxus*, the spire depression is atypical. This family is very rare in the American Gulf Coast Eocene, only one specimen having been described so far, *Neritina unidentata* Aldrich, 1911 from the Lower Eocene Hatchetigbee Formation. The author has another six specimens of neritids from the Eocene of Alabama and Texas but none of those can be assigned to *Theodoxus*. *Theodoxus* is rare today in the U.S.; Abbott (1974) records only one species, *Theodoxus (Vittoclithon) lu-*

teofasciata Miller, 1879 and a Miocene representative of *Theodoxus* has been reported recently by Smith (1986) from Baja California. A similar spire depression is also seen in many specimens of *Neritina virginica* (Linnaeus, 1758).

Etymology.—The specific name *domicilium* (Latin, house), refers to the atypical callus pad (vernacular for house).

Type information.—Holotype: PRI 30328. Type locality: locality 20.

Material examined.—One specimen, 5.0 mm in width.

Order **CAENOGASTROPODA** Cox, 1960, p. I311

Suborder **NEOTAENIOGLOSSA** Haller, 1882

Superfamily **CERITHIOIDEA** Fleming, 1822, p. 491

Family **LITIOPIDAE** Gray, 1847a, p. 155

Genus **LITIOPA** Rang, 1829, p. 306

Type species.—Litiopa melanostoma Rang, 1929, by original designation. Pelagic on floating seaweed.

Diagnosis.—Shell small, elongate-conic, whorls smooth or with fine spiral lines that are stronger basally. Protoconch very small and axially striate. Body whorl about half the length of the shell. Aperture entire, oval-elongate; columella concave, strongly ridged anteriorly; outer lip thin, weakly basally notched.

Remarks.—Recent species of *Litiopa* are much thinner-shelled than all Eocene or Oligocene species that were examined. The genus is epifaunal on floating algae, particularly *Sargassum*. Well preserved specimens from the early and middle Claibornian can be recognized by the minute vertical striae on the protoconch. Without the diagnostic sculpturing on the protoconch whorls, specimens could be confused with *Astyris*, a genus known from the Eocene to Recent and primarily found in northern seas.

Litiopa texana, new species
Plate 14, figures 13–14

Description.—Whorls eight, protoconch of four whorls, the first two smooth, inflated and slightly flattened, the next two with minute close-set parasigmoidal threads crossed by three spiral threads. Adult sculpture begins sharply, whorl profile almost flat and with eight to nine close-set flattened ribs, the two ribs bounding the channeled suture being the most prominent. Outer lip smooth, crenate within, and sharp-edged; aperture rounded, rhombohedral. Margin of labrum concave and margined below by a slight swelling, canal straight-sided, strongly bent to the left, siphonal fasciole weak.

Remarks.—Specimens of this genus appear to be uncommon in the early Tertiary; Palmer and Brann (1966) list only two species from the Paleogene of the Gulf and Atlantic coastal plain. Two species are also known from the Eocene of the Paris Basin. Tracey (pers. comm.) reports finding specimens of *Litiopa* from the Eocene Bracklesham and Barton formations in England. Specimens of this genus are more abundant than the previous records would indicate, as I have found several specimens of a closely similar, and so far undescribed form from the Cook Mountain Formation. None of the previous descriptions of the Eocene species mentions the axial striations on the protoconch; Tracey (pers. comm.) reports that feature is present on all the Eocene Paris Basin and English specimens. All the English, French and Texas specimens have strong spiral lines on the protoconch with the vertical ribbing present in the interstices. The present species *L. texana*, can be separated by its flatter whorls, stronger spiral lines and shallower sutures. The unnamed Cook Mountain Formation species is shorter, with more inflated whorls, and weaker spiral sculpture. I am indebted to Steve Tracey for recognising the genus *Litiopa* in the Reklaw, and for communicating valuable information on the English and French species.

Etymology.—Noting the discovery of the genus in Texas.

Type information.—Holotype: PRI 30386; paratype: PRI 30387, a juvenile. Type locality: locality 20.

Material examined.—97 specimens, the largest: 5.0 mm length, 2.8 mm width.

Subfamily **BITTIINAE** Cossmann, 1906a, p. 61

Genus **BITTIUM** Leach in Gray, 1847b, p. 270

Type species.—Murex reticulatus Montague, 1803, by subsequent designation (Gray, 1847, p. 154). Recent in European seas.

Diagnosis.—Shell solid, small, slender and nodose. Protoconch with about two and a half smooth or spirally lirate whorls. Adult whorls flattish, usually three with noded spiral lines, axial ribs and irregular varices. Aperture ovate, inner lip concave, outer lip thin, smooth, not reflected, short anterior notch present, not reflected backwards.

Remarks.—Houbrick (1977) reevaluated the genus *Bittium* and found no justification for the separation into subgenera on conchological grounds alone, given the high degree of variability and cosmopolitan distribution seen in this genus. The genus ranges from the Paleocene to Recent.

Bittium tresquatrum, new species
Plate 10, figures 15–16

Description.—Shell solid, high, small, to 12 mm in length. Whorls about 16 in number, the first one or two nuclear whorls missing in all specimens found. First two extant whorls smooth, squat and medially carinate, the next two with two spiral lines, the anterior one developing first. Adult whorls moderately convex with about 18 to 22 broad longitudinal costae and one varix every three-quarters of a whorl, the whorls overridden by five broad flattened spiral cords, the posterior one margining the suture. The posterior three cords are larger and more prominently noded than the other two. The interstices between the cords with one to three fine spiral striae, the growth lines forming a broad open C. Basal disc present and margined by a sixth cord, the disc showing a few weak spiral lines. Aperture oval, outer lip with a varix in the adult, labrum with a few short lirae. Inner lip reflected with a moderately thick wash of callus, columella straight with one thin acute fold, short anterior notch present.

Remarks.—Bittium is an uncommon genus in the Eocene of the Gulf and Atlantic coastal plains. The previously known North American species can be split into two groups, the first, represented by subgenus *Stylidium* Dall *in* Bartsch, 1907, is characterized by generally smooth shells with weak or obsolete axial sculpture; the second group is represented by *Bittium koeneni* Meyer, 1886 from the Jackson Eocene, and *Bittium (Bittium) estellense* Aldrich, 1921 from the Paleocene of Alabama and Texas. These are very small species with angular whorls and axial nodose ribs. *B. tresquatrum* shows little similarity to either of the above groups, or even to the two west coast Eocene species, *Bittium longissimum* Cooper, 1894, and *Bittium (Semibittium) quadricingulatum* Palmer, 1923. A related Eocene species is *Bittium transenna* (Bayan, 1873), from the Paris Basin. *Bittium tresquatrum* exhibits a remarkable similarity to several species of *Argyropeza* Melville and Standen, 1901, figured in Houbrick (1980), which today includes five bathyal species of small vitreous-shelled cerithids. Dockery (1984) has recognized *Argyropeza* s.l. from the Oligocene of Mississippi. The protoconch of even the best specimen of *B. tresquatrum* is somewhat abraded and the very tip is lost so a complete comparison cannot be made; what remains certainly is very similar to several *Argyropeza* species. All the Taylor Branch specimens were found inside a deep fossilized burrow, probably made by a crab or shrimp, and all show evidence of abrasion; this species may have been a favored food of the original inhabitant of the burrow.

Etymology.—The specific name refers to the constant three-quarter whorl placing of the varices.

Type information.—Holotype: PRI 30331; paratypes: PRI 30332, 30333. Type locality: locality 4.

Material examined.—154 specimens, the largest 12 mm in height.

Bittium ridgei, new species
Plate 10, figures 10–11

Description.—Shell very small, slender, solid. Juvenile whorls unknown. Adult whorls bicarinate, straight-sided and ornamented with three heavy spirals that are coarsely nodular where they cross over equally-sized longitudinal ribs; occasionally ribs are moderately thickened, becoming small varices. Later whorls may develop intermediate threads between the spirals and below the suture. Basal disc delimited by a smaller spiral line, and between it and the base of the columella lip a few more spiral lines, one of which is larger and continues into the aperture as a fold. Columella bent to the left, base of aperture straight, slight spout or emargination present.

Remarks.—As with *Bittium tresquatrum* there do not seem to be any close relatives of this species in the Gulf or Atlantic coastal plain. Distantly related is *Bittium koeneni* Meyer, 1886 from the Jackson Eocene. The coarse sculpture, slender straight-sided whorls, and apertural shape are sufficient to distinguish this species from other *Bittium* species.

Etymology.—Referring to the type locality, Ridge Creek, Bastrop County, Texas.

Type information.—Holotype: PRI 30334; paratype: PRI 30335. Type locality: locality 4.

Material examined.—14 specimens, the largest (broken) specimen ca. 0.4 mm. locality: locality 4.

Family **TURRITELLIDAE** Lovén, 1847, p. 194

Subfamily **TURRITELLINAE** Lovén, 1847, p. 194

Genus **TURRITELLA** Lamarck, 1799, p. 74

Type species.—Turbo terebra Linnaeus 1758, by monotypy. Recent in the Indo-Pacific.

Diagnosis.—Spire elongate, protoconch of about one and a half smooth, glassy, turbinate whorls. Teleoconch whorls usually straight sided, sometimes somewhat concave or convex, always ornamented with spiral lirae, basal lira sometimes forming a strong carina or collar. Outer lip sinuous. The genus ranges from the Cretaceous to Recent.

Turritella turneri Plummer, 1933
Plate 11, figures 13–14

Turritella sp. Plummer, 1933, p. 625.
Turritella turneri Plummer, 1933, p. 815, pl. 10, figs. 10, 10a; Sten-

zel and Turner, 1940, p. 836, pl. 47, figs. 16, 17; Stenzel and Turner, 1943, Card no. 106, figs. 10, 10a, 16, 17 (syntypes).

Turritella mortoni turneri Plummer. Palmer, 1937, p. 195 in part, pl. 23, figs. 4,5.

Turritella dumblei turneri Plummer. Bowles, 1939, p. 304.

Original description.—"Apical angle 17 1/2°, sculpture consisting of five unequal spirals, anterior spiral the largest, shape of the whorl strongly convex, posterior whorl slope slightly longer than anterior." (Plummer, 1933, p. 815)

Remarks.—This species has so far not been found in the deposits of Joe Taylor Creek, but further east in the localities of Bastrop and Caldwell Counties it is reasonably common at certain levels. Stenzel, (1953, pp. 72, 78) notes the species is locally abundant in the Newby member of Cherokee County. Bowles (1939), regarded this form as a subspecies of *Turritella dumblei* Harris, 1895a, but it is in fact more closely related to *Turritella infans* Stenzel and Turner, 1940. A similar form that could also be referred to *T. turneri* occurs in the Weches Formation of Nacogdoches County, Texas at the cut made for the Nacogdoches Lake Dam; the Weches species has stonger beading on the spirals and a somewhat smaller subsutural spiral but is otherwise very similar.

Type information.—Syntypes: P5419, Plummer Collection TBEG. Type locality: locality 1. Forney and Nitecki (1976, p. 217) state there are four syntypes at the Field Museum in Chicago, FMNH-UC 57367, only one of which could be located. Figured Reklaw specimens: PRI 33122, 33123, from locality 7.

Material examined.—84 specimens, the largest 14 mm length, 4 mm maximum diameter.

Subfamily **PAREORINAE** Finlay and Marwick, 1937, p. 42

Genus **MESALIA** Gray, 1842, p. 61

Type species.—*Turritella brevialis* Lamarck, 1822, by subsequent designation (Gray, 1847a, p. 155). Recent off the coasts of Northern and Western Africa.

Diagnosis.—Spire elongate, usually cyrtoconoid. Teleoconch whorls rounded, often highly inflated, sutures not channeled or deeply impressed, ornamented with spiral striae or lirae, lines of growth arcuate, the points of contact with the suture closely in line with the shell axis. Aperture subcircular, slightly reflected anteriorly, anterior portion of outer lip recurved.

Remarks.—The genus ranges from the Upper Cretaceous to Recent.

Mesalia sp.

Plate 11, figure 15

Remarks.—A single specimen of a *Mesalia* sp. was found in the general collection of the Texas Memorial Museum. The preservation, shape and sculpture is similar to that seen in *Mesalia* specimens from the Weches Formation at Smithville and it is possible this is a misplaced specimen. The specimen is very close to *Mesalia claibornensis* Harris, 1895b, from which it differs by an apical angle which is two to three degrees larger and having more inflated whorls. The aperture had within it a sandy glauconite matrix and two juvenile specimens of *Limacina sp.*; the matrix is similar to other Reklaw deposits and the *Limacina* species are also commoner in the Reklaw than the later Weches deposits. With some doubt this specimen is believed to be of an age equivalent to that of the Reklaw. Further collecting could resolve the matter although the locality is now covered by a thick growth of vegetation.

Figured specimen.—UT-TMM 19346, from locality 10 (=TBEG 11-T-35).

Superfamily **LITTORINOIDEA** Gray, 1840, p. 119

Family **LITTORINIDAE** Gray, 1840, p. 119

Subfamily **LITTORININAE** Gray, 1840, p. 119

Genus **LITTORINA** Férussac, 1822, p. xxxiv

Type species.—*Turbo littoreus* Linnaeus, 1758, by subsequent designation (Blainville, 1828, p. 98). Recent in north European seas.

Diagnosis.—Shell smooth or weakly sculptured, usually thick-shelled; aperture inclined to the shell axis, outer lip sharp, upper part produced adaperturally; columella smooth, excavated, flattened, umbilicus covered. Operculum chitinous, nucleus offset from the center.

Remarks.—Most Littorinidae live in the tropics, graze on algae and are primarily intertidal in distribution. The genus ranges from the Pliocene to Recent.

Subgenus **PROSTHENODON** Cossmann, 1888, p. 257

Type species.—*Littorina monodonta* Deshayes, 1865, by monotypy. Eocene of the Paris Basin.

Diagnosis.—Distinguished from *Littorina* s.s. by its more attenuated spire, the spirally striate whorls with deeply impressed sutures, and the prosocline growth lines. Columella broadly flattened and excavated with a strong tooth on the anterior margin, the margin meeting the basal lip in a sharp curve.

Remarks.—The genus is restricted to the Eocene.

Littorina (Prosthenodon) eofasciata, new species

Plate 9, figures 9–10

Description.—Shell small, whorls six, tip and first two flattened, the third with three spiral lirae, the remainder of the spire smooth or with obsolete spiral lirae, body whorl with stronger lirae and six or seven strong lines on the basal part. Aperture tear-drop shaped, abaxial margin sharply carinate, outer lip (where extant) smooth; columella thick, flattened, margin thinner anteriorly, basal margin strongly bent, approaching a columella plication in character, so forming an oblique tooth-like projection. Color pattern weakly preserved as three darker bands on the spire whorls, one or two more on the body whorl and a tendency for the basal lirae to retain a bluish tinge.

Remarks.—At least 14 species of *Littorina* s.l. have been described from the Paris Basin, the presence of the tooth-like projection is diagnostic of subgenus *Prosthenodon*, a rare taxon known from the Lutetian and doubtfully the Cusian. A comparison of *L. (P.) eofasciata* and *L. (P.) monodonta* shows the latter species is more elongated and has spiral lines over the entire shell; this species also according to Cossmann (1888, p. 257) shows traces of widely spaced but narrow color bands. A similar banded coloration is seen in the type of the genus, *L. littorea.* No littorinid seems to have been reported previously from the Gulf Coast or East Coast Paleogene of the United States. A single species, *Littorina subobesa* Cooper, 1896, has been reported from the Marysville Eocene of California; the holotype, according to Keen and Bentson (1944, p. 168), was probably destroyed in the San Francisco fire of 1906; it was not mentioned by Dickerson (1913), in his faunal report on the Marysville.

Etymology.—Referring to the color banding on this Eocene species.

Type information.—Holotype: PRI 33100, 4.3 mm length; paratype: PRI 33101. Type locality: locality 4.

Material examined.—Three specimens, the largest is damaged, but is estimated to have been 7.9 mm long.

Superfamily **TRUNCATELLOIDEA** Baker, 1956, p 29

Family **VITRINELLIDAE** Bush, 1897, p. 107

Subfamily **VITRINELLINAE** Bush, 1897, p. 107

Genus **CYCLOSTREMISCUS** Pilsbry and Olsson, 1945, p. 266

Type species.—Vitrinella panamensis C. B. Adams, 1852, by original designation. Recent western Panama and Mazatlan.

Diagnosis.—"The shell is small or minute (usually less than 3 mm. in diameter), solid or moderately strong, depressed or discoidal, much wider than high, umbilicate, of few (about three more or less) whorls, of which the first one and one third to two form a smooth nuclear shell. Last whorl typically having several spiral angles or carinae, their intervals typically with lower axial riblets or striae. Aperture subcircular or modified by the angles of the shell, the peristome continuous, not thickened externally" (Pilsbry and Olsson, 1945, p. 266).

Remarks.—The genus is abundantly represented in the tropical seas of the west coast of America. The genus ranges from the Upper Cretaceous to Recent.

Cyclostremiscus axacuus (Conrad, 1833b)
Plate 9, figures 11–12

Solarium axacuum Conrad, 1833b, p. 44.

Delphinula plana I. Lea, 1833, p. 117, pl. 4, fig. 104; H. C. Lea, 1849, p. 99; Harris, 1895c, p. 34.

Solarium exacuum Conrad *in* Morton, 1834, p. 3; Conrad, 1835, p. 48, pl. 17, fig. 5; H. C. Lea, 1849, p. 105; de Gregorio, 1890, p. 135 in part, pl. 12, figs. 33, 34 copy *S. plana* Lea, figs. 35, 36 copies Conrad figs. 37–39; not figs. 40, 41 copy *S. delphinoides* Meyer = *Circulus ottonius* Palmer; Harris, 1895c, p. 19.

Solarium Exacutum [sic] Conrad. d'Orbigny, 1850, p. 348.

Architectonica exacuua (Conrad). Conrad, 1865a, p. 29; 1866a, p. 13.

Achitectonica plana (I. Lea). Conrad, 1865a, p. 30; 1866a, p. 13.

Adaeorbis exacua (Conrad). Dall, 1892, pp. 331, 344, 347.

Adaeorbis exacuus (Conrad). Cossmann, 1893, p. 252.

Tornus (Adaeorbis) exacuus (Conrad). Cossmann, 1918, p. 98.

Circulus exacuus (Conrad). Palmer, 1937, p. 53, as *exacuum*, pl. 5, figs. 28, 34, 37; Brann and Kent, 1960, p. 222; Glibert, 1962a, p. 71.

Cyclostremiscus exacuus (Conrad). Palmer and Brann (1966), p. 618; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, pp. 19, 31.

Original Description.—"Discoid, with revolving acute lines; whorls with a wide indentation at the suture; submargin widely indented, and the periphery acutely carinated; beneath flattened; umbilicus smooth, aperture subovate." (Conrad, 1833a, p. 44)

Remarks.—As Palmer (1937, p. 53–54) noted there are two forms within this species, one with more rounded whorl profile and a greater number of spiral lines than the other. Both forms start with three spiral lines on the first post-nuclear whorl. Palmer and Brann (1966, p. 616) list the species as also occurring in the Cook Mountain Formation of Texas and the McBean Formation of South Carolina. Typical *C. axacuus* is fairly common throughout the marine Claiborne in Texas; a second species is also present that starts its post-nuclear whorls with two strong spiral lines. The Reklaw Formation specimens of *C. axacuus* are within the limits of variation of the species from the Weches and Cook Mountain formations but as a group the Gosport Sand Formation specimens might be separated by their greater size, the wider flat area margining the umbilicus and the imbricate character of the growth lines in the umbilicus. There are, however, Gosport Sand Formation specimens that fit well within the Texas group; the converse has not been observed. Conrad (1833b, pp. 39, 44) named the species *Solarium axacuum* accompanied by a description and used the same name in his list of species in the contents; Conrad (1835, p. 48, pl. 17) renamed it *Solarium exacuum*. All succeeding authors have treated the 1833 spelling as an error. Unfortunately, according to the ICZN, Art. 32 (c) (ii), it "requires clear evidence of an inadvertent error" to designate an incorrect original spelling; Moore (1962, p. 59) notes *Solarium exacuum* in Conrad's handwriting on the specimen card in the ANSP, but this falls under the "external information" sentence in the same section of the code cited above and so is inadmissible as a reason for change.

Type information.—Lectotype: ANSP 15389. Type locality: Claiborne Bluff, Monroe County, Alabama. Figured Reklaw specimen: PRI 33102, from locality 4.

Material examined.—Ten specimens, the largest: 3.3 mm greatest diameter, 1.0 mm thickness.

Family **SKENIDAE** Clarke, 1851, p. 472

Genus **TUBIOLA** A. Adams. 1863a, p. 74

Type species.—Turbo nivea A. Adams, 1863, by subsequent designation, (Kobelt, 1879, p. 154). Recent, Sea of Japan.

Diagnosis.—"Shell very small to small, similar to *Skena,* moderately high to discoid in shape. Whorls rounded, with spiral lines, body whorl large, sutures deeply impressed. Last whorl large, umbilicus funnel-shaped, columella thickened, aperture circular to oval, entire, set at an angle to the shell axis." (trans. from Wenz 1938, p. 327)

Remarks.—The genus ranges from the Eocene to Recent.

Tubiola gracilis, new species

Plate 9, figures 13–14

Description.—Shell very small, thin-shelled, three and three-quarter whorls. Nucleus small, rounded and flattened. Whorls flattened posteriorly, only very lightly in contact, surface smooth, or with microscopic growth lines. Peristome entire, rounded, posteriorly produced, the edge swinging back below the flattened posterior area. A few stronger lines of growth, thickened threadlike, can be seen behind the aperture. Umbilicus rounded, deep, within with more prominent growth lines.

Remarks.—This species has a remarkably thin shell and that feature is no doubt responsible for the paucity of specimens. The only other species known from the Gulf Coast Paleogene is *Tubiola nautiloides* (Aldrich, 1910b) from the Cook Mountain Formation of Mississippi, distinguished by its smaller umbilicus, a different apertural profile and a body whorl extending free of the previous whorl. Palmer (1937, pl. 21, fig. 10) figures a species, *"Adeorbis" incertus* (de Gregorio, 1890), which is suggestively like *T. gracilis* but the description is not good enough for a meaningful comparison, and the specimen is lost. The generic placement is in some doubt as the type, *T. nivea* has a thickened columella while in the new species that is only marginally so. The very thin shells of *T. gracilis* could imply a pelagic existence for the animal and three possibilities suggest themselves. As the shell is dextrally coiled it is unlikely to be a pteropod and even if these are assumed to be abnormally coiled specimens, no known coiled Eocene pteropod is at all similar in shape or size. Two heteropod families are known from the Eocene of the Paris Basin, the Atlantidae and the Carinariidae. The Atlantidae are planispirally coiled and from the illustrations in van der Spoel (1976) have a swollen nucleus, and initial whorls offset from the shell axis. These are represented by *Eoatlanta,* Cossmann, 1889; a dextrally coiled genus, usually keeled, or with a triangular shaped aperture. The other heteropod family, Carinariidae, might be considered, and one genus in that family, *Cardiapoda* d'Orbigny, 1836, has a similar shell. The shell is typically extremely minute, however, and after a few planispiral whorls the shell is greatly enlarged. The pelagic family Janthinidae are not known in the fossil state; they have an asymmetrical cylindrical protoconch and are not planispiral in form.

Etymology.—The specific name *gracilis* (Latin, thin), refers to that feature of the shell.

Type information.—Holotype: PRI 30316. Type locality: locality 20.

Material examined.—Three specimens, the largest: 2.9 mm maximum diameter, 1.5 mm height 1.5 mm.

Genus **SOLARIORBIS** Conrad, 1865a, p. 30

Type species.—Delphinula depressa I. Lea, 1833, by subsequent designation (Dall, 1892, p. 414). From the Gosport Sand Formation, Eocene of Alabama.

Diagnosis.—Shell small, depressed, moderately thick shelled. Nucleus small but fairly prominent, smooth and shining, paucispiral. Surface smooth or with punctate spiral lines. Aperture holostomous; peristome angulated and slightly sulcate at the commissure. Parietal wash heavy, umbilicus small, partially covered by the thickening of the umbilical carina.

Remarks.—Conrad proposed this genus in a heading for a list of four disparate shells, Dall designated the first as type, the others now being referred to the genera *Solariella* (Wood, 1842), *Norissia* (Bayle, 1880) and *Cirsochilus* (Cossmann, 1888). The genus is restricted to the Tertiary. Modern members of the Vitrinellidae are reported to feed on algae and to be parasitic on worms.

Solariorbis discoides, new species
Plate 9, figures 15–16

Description.—Shell very small, diameter 2 mm, rounded, discoidal. Whorls four, nucleus flattened, spire convex, whorls rapidly expanding. Body whorl flattened above and below, evenly rounded at the edge. Suture impressed and margined below by a narrow depression. Surface smooth and polished, the upper surface smooth or spirally striate, lines of growth microscopic in size only. Aperture round, margin strongly oblique, thickened near the basal callus which is lunate in shape and projects back partially over the umbilicus. Area between the basal margin and thickened region with at least two faint spiral grooves. Umbilicus small, obscurely margined by the thickened callus.

Remarks.—The closest relative seems to be *Solariorbis rotulus* (Heilprin, 1879) from the Gosport Sand Formation, where the sutural region is developed as a wide concavity rather than a groove. When a large suite of specimens is examined it is found that the presence or absence of spiral lines cannot be used as a distinguishing characteristic. Most specimens are dorsally smooth but a continuous graduation does exist to entirely spirally striate examples. One specimen shows an abrupt transition from the smooth stage to the spirally striate stage. Generally, juvenile specimens are free of spiral ornament while one or more lines are developed in the adult. Characters distinguishing *S. discoides* from *S. rotulus* and other more distantly related species are the sharp rim of the callus on the expanded outer lip and the non-punctate character of the spiral lines. Very faint traces of nacre are visible on some specimens, and since these are typical of *Solariorbis* as now understood, they could make the placement of the genus within the Vitrinellidae doubtful.

Etymology.—The specific name *discoides* (Latin, disc shaped), refers to the discoidal shape of the shell.

Type information.—Holotype: PRI 30317; paratypes: PRI 30318, 30319. Type locality: locality 20.

Material examined.—200+ specimens, the largest 2.0 mm width.

Solariorbis conicus, new species
Plate 9, figures 17–18

Description.—Shell very small, solid, three and three-quarter whorls. Nucleus minute and seemingly partially immersed. Whorls smooth, rapidly expanding, early whorls convex, later ones straight to slightly concave, profile of spire approximating that of a low cone. Suture impressed and ragged on later whorls. Body whorl rounded, base flat to concave, umbilicus small and partially obscured by a slight thickening of the basal apertural callus.

Remarks.—This species is readily distinguishable from other *Solariorbis* species by the cone-shaped profile and smooth whorls. No subsutural depression or basal umbilical callus is apparent, although a pronounced color change in many specimens indicates its position. Larger specimens have the later whorls encroaching considerably over the previous ones which in one specimen almost completely envelops the protoconch. This species is restricted to the highest fossiliferous bed at Ridge Creek.

Etymology.—The specific name refers to the conical profile.

Type information.—Holotype: PRI 30320; paratypes: PRI 30321, 30322. Type locality: locality 7.

Material examined.—75 specimens, largest specimen 2.03 mm width.

Solariorbis? parsnaticoides, new species
Plate 9, figures 19–20

Description.—Shell very small, ca. 1 mm diameter, solid, globose. Whorls three and one-half, nucleus partially immersed within the succeeding whorl. Sutures moderately impressed, whorls smooth or showing lines of growth. Spire whorls carinated, flattened above and below the carina. Body whorl rounded-bicarinate, the lower carina more acute, curving smoothly below to the base. Aperture rounded-quadrate thickened from the lower margin to a point a little past the upper suture and expanded into a large tongue where it meets a smooth umbilical rib. Umbilicus wide and defined by a carina at the outer edge and partially covered over by the reflected columella margin.

Remarks.—This is a very difficult species to place, even to the family level. The characters seen in *Solariorbis conicus* n. sp. are accentuated to an even greater degree here. The smooth whorls, high profile and lack of a margining umbilical callus are not typical of *Solariorbis* s.s. although the umbilical cord ending in a planed-off callus lobe is distinctive of that genus. They are unlikely to be juvenile shells with three and one-half whorls, a typical number for many *Solariorbis* species. Pilsbry and McGinty (1945) introduced the subgenus *Diagonaulus* within *Didianema* for a group of small globose vitrinellids with a carinate or strongly angulated umbilicus and these shells are very similar to those in shape. A distinguishing characteristic of *Diagonaulus,* however, is a narrow shelf within the aperture (for probable placement of an operculum) and these specimens lack that feature. *Heniastoma* Cossmann, 1918 might also be considered but species of this subgenus of *Collonia* J.E. Gray, 1850b are depressed and instead of an umbilical cord there is an angulation ending at a moderately flared outer lip. *S. parsnaticoides* has only been found at locality 14, where the most extreme dwarfing of the fauna is apparent.

Etymology.—The specific name *parsnaticoides* (Latin, Natica-like), refers to the similarity to a *Natica* shape.

Type information.—Holotype: PRI 30323; paratypes: PRI 30324–30326. Type locality: locality 14.

Material examined.—12 specimens, the largest ca. 1.4 mm. width.

Subfamily **TEINOSTOMINAE** Cossmann, 1917, p. 210

Genus **TEINOSTOMA** H. and A. Adams, 1853, p. 122

Type species.—*Teinostoma politum* A. Adams, 1853, by subsequent designation (Cossmann, 1888, p. 44). Recent from Santa Elena, Ecuador.

Original diagnosis.—Shell orbicular, depressed, subspiral, polished, last whorl rounded at the periphery; umbilical region covered with a large flat callosity; aperture transverse, rounded, greatly produced and elongated, ending anteriorly in a slightly caniculated point; inner lip smooth, callus not emarginate or truncate anteriorly; outer lip thin, simple, not margined or reflected.

Remarks.—The genus rangs from the Upper Jurassic to Recent.

Teinostoma cf. **texanum** Palmer, 1937
Plate 9, figures 21–22

Teinostoma texanum Palmer, 1937, p. 46, pl. 2, figs. 20–22; Brann and Kent, 1960, p. 837; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, p. 11.

Original Description.—"Shell medium, about three and one-half whorls, not enveloped and not elevated; sides of body whorl rounded; umbilicus covered completely with a solid callus; surface smooth." (Palmer, 1937, p. 46)

Remarks.—One juvenile shell was obtained which agrees very well with *T. texanum,* a species described from the Stone City Member of the Sparta Formation.

Type information.—Holotype: PRI 2658. Type locality: Stone City bluff (type), Burleson County, Texas. Figured Reklaw specimen: PRI 33103, from locality 20.

Material examined.—One specimen, 0.5 mm maximum diameter.

Superfamily **STROMBOIDEA** Rafinesque, 1815, p. 19

Family **STROMBIDAE** Rafinesque, 1815, p. 19

Genus **ECTINOCHILUS** Cossmann, 1889, p. 57

Type species.—*Strombus canalis* Lamarck, 1803, by original designation. Eocene of the Paris Basin.

Diagnosis.—Shell high, tapering, varicose and costate. Whorls convex with longitudinal ribs and fine spiral lines. Aperture anteriorly wide and notched, posteriorly also notched and bordered with callus which extends onto the spire whorls. Outer lip extended and thickened, smooth within; columella broadly concave and smooth.

Remarks.—The genus ranged from the Paleocene to Oligocene and was widely distributed in Eocene times.

Ectinochilus sp.
Plate 14, figure 10

Remarks.—One very small fragment was obtained consisting of three smooth protoconch whorls and two and a half adult whorls. It appears similar to *Ectinochilus texanum* (Harris, 1895a), but with more convex whorls and stronger ribs. This records the presence of this genus in the Reklaw.

Figured specimen.—PRI 30380, from locality 4.

Superfamily **VANIKOROIDEA** Gray, 1840, p. 121[4]

Family **FOSSARIDAE** Troschel, 1861, p. 153

Genus **POSTALIA** Oppenheim, 1896, p. 165–166

Type species.—*Postalia postaliensis* Oppenheim, 1896, by original designation. Eocene of Monte Postale, northern Italy.

Diagnosis.—Shell medium in size, of two and a half whorls with very deeply impressed sutures, the last whorl comprising almost the entire shell. The first one and a half whorls are similar to an *Adeorbis,* with a globose protoconch that develops stronger spiral sculpture on the last whorl. The last whorl making up the adult shell expands very rapidly, opening out trumpet-like, the aperture in a plane parallel to the axis. The outer lip is simple, the columella thin, vertical and defining one edge of a deep but narrow umbilicus. The ornament consists of narrow spiral ribs, 22 on the last whorl, 12 on the preceding. (Free translation of Oppenheim, 1896, pp. 165–166)

Remarks.—The genus is restricted to the Eocene. Wenz (1940, p. 884) regarded the placement within the Fossaridae as doubtful, but did not suggest an alternative. The genus does not seem to have been commented on since.

Postalia americana, new species
Plate 13, figures 11–14

Description.—Whorls four to four and three-quarters, rounded discoidal, flattened anteriorly and barely or not at all in contact. Nucleus immersed but may possibly be eroded. Protoconch large, rounded, of three volutions and with six to seven spiral lines ending in a rib. The first half whorl of the adult shell is smooth and rounded except for lines of growth, thereafter the whorls develop a sculpture of widely spaced rounded costae of gradually increasing strength, crossed by lines of growth giving the surface a rough muricate appearance. The protoconch and first one and a half adult whorls are at an acute angle of about 30° to the shell axis. Outer lip thin, trapezoidal in shape, the lower margin widely flaring and comarginal with the external costae. Base of body whorl with stronger ornament than the upper surface and with a wide umbilicus.

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[4] *Nomen trans.* Ponder and Warén, 1988.

Remarks.—These specimens might be regarded as abnormalities, particularly in regard to the change of shell axis but all three specimens show the same feature. The only other species in this genus is the type from Northern Italy. As Oppenheim (1896) notes, the systematic placement is problematical, perhaps as that author surmises the shape of the shell is connected with some form of parasitism on crinoids. A somewhat similar recent American species is *Cyclothyca corrugata* Sterns, 1890, questionably from the west coast of Nicaragua; only one specimen has been discovered.

Etymology.—Noting the first occurrence of the genus in the New World.

Type information.—Holotype: PRI 30369; paratype: PRI 30370. Type locality: locality 20.

Material examined.—Three specimens, the largest (with some flattening on the body whorl) 15.0 mm width, 8.0 mm length.

Superfamily **VERMETOIDEA** Rafinesque, 1815, p. 144[5]

Family **VERMETIDAE** Rafinesque, 1815, p. 144

Genus **SERPULORBIS** Sassi, 1827, p. 482

Type species.—Serpulorbis polyphragma Sassi, 1827, by original designation. Tertiary of northern Italy.

Diagnosis.—Tubes either free or attached, irregularly wound, often a flat spiral. Adult sculpture of three or more rough nodose longitudinal costae, broken feeding tubes often present on larger specimens.

Remarks.—Recent representatives of the genus are mucus feeders, entrapping floating food particles and pulling them back at intervals. The Vermetidae are difficult to classify, having in the past been confused even up to phylum level. They may be distinguished from annelid worms by the three-layered shell, the inner surface glassy. *Lemintina* Risso, 1826, often cited instead of *Serpulorbis*, is a *nomen nudum* having being described from an annelid. In the absence of nuclear whorls the assignment of the following species follows general usage by other authors. The genus is known from the Upper Cretaceous to Recent.

Serpulorbis multiclavus, new species

Plate 11, figures 16–17

Description.—Shell attached, colonial, irregular in growth direction. No protoconch observed, juvenile shell with concentric rounded costae and somewhat triangular in crossection. The free apex becomes progressively ridged and more spinose, with increasing age other ridges develop and finally the entire set of longitudinal ridges develops a series of sharp irregularly spaced spines. The internal profile remains circular at all stages of growth. The rounded concentric costae and spines are often hollow and develop holes which do not continue through to the interior of the shell.

Remarks.—There seem to be no close analogs to this species in the Claibornian. *Tenagogus (Agathires) texanus* Palmer, 1937 from the Cook Mountain Formation, might superficially be taken to be this species due to some similarity in external sculpture, but in that species the holes occur in linear rows, continue through to the interior of the tube, and correspond to the external slit band seen in *Tenagogus s.s.* Adult fragments of sculpture are very irregular in character, the concentric costae become irregular swellings, often merge with one another, and develop secondary irregular patterns.

Etymology.–The name notes the multiple ornamented stripes on the tubes.

Type information.—Syntypes: PRI 30345–30349. Type locality: locality 4.

Material examined.—At least 60 fragments of tubes and colonial masses.

Superfamily **CYPRAEOIDEA** Rafinesque, 1815, p. 146

Family **OVULIDAE** Fleming, 1828, p. 331

Subfamily **OVULINAE** Fleming, 1828, p.331

Genus **NEOSIMNIA** Fisher, 1884, p. 664

Type species.—Ovula sepelta Linnaeus, 1758, by monotypy. Recent in the Mediterranean.

Diagnosis.—Shell small to medium sized, elongate, medially inflated, sometimes with an obliquely carinated columella. Dorsum smooth, or more usually spirally striated; anterior and posterior ends spirally striated. Aperture wider anteriorly, columella with an oblique callus plication. Outer lip flattened, smooth or finely toothed, bent anteriorly. Inner dentition rarely developed. Terminal ridge weak or absent.

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[5] *Nomen transl.* Pchelintsev and Korobkov, 1960.

Remarks.—Modern species are most abundant in warm seas and feed primarily on gorgoniae and corals. The genus ranges from the Eocene to Recent.

Neosimnia scobina, new species
Plate 13, figures 9–10

Description.—Shell small, elongate, outer lip almost straight medially, attenuate at both ends, maximum diameter of base at about one-quarter of the length from the posterior end. Shell smooth medially, excepting at both ends, where under a microscope a few very faint, close together, spiral lines may be seen. Outer lip with about 46 small similarly-sized small teeth. Inner lip with about 33 small teeth gradually decreasing in size posteriorly, disappearing just above the point of maximum inflation, the two terminal teeth slightly more elongate and oblique. A small smooth fossula just visible. Posterior end of the inner lip with a thick pad of callus which is the terminal end of an oblique columella fold.

Remarks.—Two specimens were found, both somewhat crushed, and showing signs of abrasion. The dentate aperture, straight central part of the outer lip and a posterior callus pad is also seen in *Transovula (Oxycypraea) naviculae* Palmer, 1937, which is one of three Eocene Clairbornian species Palmer and Brann, 1966, assign to this taxon. Luc Dolin (pers. comm.) places *T. (O.) naviculae* in *Prosimnia* Schilder, 1927. Palmer's species is not as elongate and possesses 25 fine teeth on the outer lip and a lirate inner lip with about 20 strong teeth; in addition the callus pad is not of the same character as *N. scobina,* being terminated abruptly within the aperture, there forming a sharp adapical ridge. *Transovula* de Gregorio, 1880 is usually medium to large in size, dentate on the outer lip, and usually also on the inner lip, the end tooth composed of one to two small folds. *Prosimnia* is small, cylindrically striated, and carinated to some degree above the center, a shape and sculpture quite unlike that of the Reklaw species. The Reklaw specimens are similar to *Neosimnia texana* (Johnson, 1899), although the latter is a more attenuated species, has weaker dentition and three or four grooves at the posterior end instead of the callus pad. The dentition of *N. texana* is probably a variable character; specimens in the author's collection range from weakly dentate to non-dentate. Another dentate species, *Neosimnia regularoides* (Aldrich, 1921), is found in the Lower Eocene at Bells Landing, Alabama. This species is more evenly rounded, and has a narrower aperture and fine revolving lines on the posterior half of the shell. Unfortunately the holotype was broken after figuring, but the fragments still show the details necessary for assignment.

Etymology.—Referring to the fine rasp-like teeth.

Type information.—Holotype: PRI 30379; paratype: PRI 30292. Type locality: locality 4.

Material examined.—Two specimens, the largest (the holotype): 13.5 mm length.

Family **CYPRAEIDAE** Rafinesque, 1815, p. 146

Subfamily **CYPRAEORBINAE** Schilder 1927, p. 97

Genus **CYPRAEORBIS** Conrad, 1865a, p. 31

Type species.—*Cypraeorbis lineata* Conrad, 1848a, by monotypy. Oligocene, Byram Formation of Mississippi, United States.

Diagnosis.—Shell oval to pyriform, aperture posteriorly expanded. Back usually smooth and with one or more brown spots. Both ends sometimes caniculate and appearing notched in the dorsal view. Columellar teeth set back from the margin, end tooth deeply set and forming an elongate weak terminal ridge.

Remarks.—The genus ranges from the Upper Cretaceous to Recent.

Cypraeaorbis bulbus, new species
Plate 13, figures 5–6

Description.—Shell medium in size, prominently pyriform and inflated, acuminate anteriorly. Rear smooth and showing the faint outline of a large dark oval spot. Aperture sinuous, large and flaring anteriorly. Outer lip thickened, constricted in the lower third, and bearing 25–27 fine elongate teeth, columellar teeth 22–25 in number, the last three at a progressively more acute angle to the shell axis, terminal ridge thin, fossula flat to rounded, the inner teeth continuing over the posterior two-thirds. The anterior edge of the aperture sharply ridged, the columella side almost straight and weakly reflected.

Remarks.—In general Cypraeidae are very uncommon within the Eocene of the coastal plain although it has been my experience that within a few very restricted areas they are far less so. The Reklaw species is closest to two Jackson Eocene species: *Cypraeorbis towncreekensis* (Dockery, 1977), and *Cypraeorbis ventripotens* (Cossmann, 1903) than to any Clairbornian species, and can be separated by the constriction of the outer lip, the smooth dorsal surface, the greater inflation, and the obtuse angle of the anterior notch. All specimens of *C. bulbus* were found embedded in a large mass of water-worn coral fragments of the Madreporitidae family, which strongly suggests that these Eocene Cypraeidae had association with corals similar to that of modern representatives of the family. The two complete specimens share the shallow depression on the outer lip, one third of the distance from the anterior end, a feature that is not present on another five fragments of outer lips; it is possible that two species are present, but this cannot be confirmed with the present material at hand. The large colored spot seen in many modern representatives of this family is also seen as a darker area on the fossil specimens.

Etymology.—Referring to the prominent bulb-like shape of this species.

Type information.—Holotype: PRI 30371; paratype: PRI 30372. Type locality: locality 21.

Material examined.—Eight specimens (two complete), the largest (the holotype): 32 mm length, 23 mm maximum diameter.

Superfamily **NATICOIDEA** Forbes, 1838, p. 29[6]

Family **NATICIDAE** Forbes, 1838, p. 29

Subfamily **AMPULLOSPIRINAE** Cox, 1930, p. 170

Genus **AMAURELLINA** Fisher, 1885, p. 776

Type species.—Ampullaria spirata Lamarck, 1804, by monotypy. Eocene of France.

Diagnosis.—"Shell small to medium sized, moderately elongate, spire elevated, shoulder narrowly channeled, umbilicus narrowly to moderately open, umbilical callus absent, inner lip reflected. A slender cord arises on the thickened anterior inner lip and enters the umbilicus. Shell smooth or with fine spiral ornament." (Marincovich, 1977, p. 241)

Remarks.—The genus is reported from the Lower Cretaceous to the Oligocene. According to Marincovich (1977), the ampullospirids are amongst the earliest known naticids and probably ancestral to the other naticid groups. Modern representatives of the family are primarily Arctic or boreal in deep water.

Amaurellina plummeri, new species

Plate 12, figures 10–11

Description.—Shell small to medium in size, spire elevated, whorls six and a half, rounded below and with a subsutural shelf. Suture deeply impressed, channeled on later whorls. Surface covered with minutely punctate, fine spiral lines, the lines coarser and more crowded subsuturally. Occasional weaker intermediate striae also occur, more prominently on the base. Lines of growth not visible except as color changes in the shell. Anterior lip thickened below the umbilicus, umbilical cord small and flattened. Wide and shallow anterior spout present, peristome continuous.

Remarks.—Three species of *Amaurellina* have previously been reported from the Eocene of North America: *Amaurellina singleyi* (Harris, 1895a), from the lower Claiborne of Lee County, Texas, *Amaurellina caleocia* Vokes, 1939, from the Domengine Formation of California, and *Amaurellina* sp. Richards, 1950, from Wake County, North Carolina. The Claiborne species from Lee County is lost, *fide* Palmer and Brann (1966). The present species can be distinguished from the preceding by the proportionately slimmer outline and more evenly rounded whorls.

Etymology.—In honor of F. B. Plummer who collected the Texas Memorial Museum specimens.

Type information.—Holotype: UT-TMM 3583; paratype: UT-TMM 3582. Type locality: locality 10.

Material examined.—44 specimens, the largest (the holotype), 12.0 mm in height.

Subfamily **NATICINAE** Forbes, 1838, p. 29[7]

Genus **NATICA** Scopoli, 1777, p. 392

Type species.—Nerita vitellus Linnaeus, 1758, by subsequent designation (Anton, 1839, p. 31). Recent in the Indo-Pacific.

Diagnosis.—Shell small to medium sized, globose, with a low to moderately elevated spire. Surface generally smooth. Usually umbilicate, with a funicle and umbilical callus; aperture holostomatous, semicircular or ovate; outer lip sharp.

Remarks.—The Naticas are active carnivores preying on other bivalves, gastropods and scaphopods. The range of the genus is Paleocene to Recent.

Subgenus **NATICARIUS** Duméril, 1806, p. 64

Type species.—Nerita canrena Linnaeus, 1758, by monotypy. Recent in the West Indies and southeastern United States.

Diagnosis.—"Shell small to medium in size, globose to somewhat elongate, body whorl distinctly inflated. Axial sculpture of sharply incised grooves that extend from suture part way to periphery. Umbilicus usually narrow, rarely broad, with moderately to deeply excavated sulcus. Umbilical callus slender; funicle ranges from robust, to low and indistinct. Parietal callus thin to slightly thickened. Operculum with one or two ribs at outer margin or several ribs over outer portion." (Marincovich, 1977, pp. 371–372)

Remarks.—The subgenus is known from the Eocene to Recent.

Natica (Naticarius) brevisulcata, new species

Plate 12, figures 12–14

Description.—Shell medium sized, of five and three-quarter whorls, nucleus minute and flattened. Suture deeply impressed, channeled, and with short to obsolete radiating sulci that continue as striae over the entire surface of the body whorl. Whorls flattened below the suture, margined by a few striae in the adult, below that regularly rounded. Aperture semilunate, outer lip sharp, columella thin, straight and at an angle of about 20° to the shell axis. Base slightly produced, columella feebly reflected over the posterior end of the umbilicus. Basal margin of the umbilicus strongly carinated in the adult, obscurely so in juvenile specimens. Umbilical interior coarsely spirally striate, slightly convex in the middle where the spiral striae are more prominent.

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[6] *Nomen transl.* Thiele, 1929, p. 259 (*ex* Naticidae, Forbes, 1838).

[7] *Nomen transl.* Wenz, W., 1941, p. 1039 (*ex* Naticidae Forbes, 1838, p. 29).

Remarks.—This species combines may of the features of *"Natica" gilberti* Palmer from the Lower Eocene Hatchetigbee Formation, 1937 and *Natica (Tella) magnoumbilicata* (I. Lea, 1833) from the Gosport Sand Formation. It agrees with *"N." (N.) gilberti* in general shape, character of the suture, and the striated interior of the umbilicus. The radiating striae below the suture and callus reflected over the umbilicus is characteristic of *N. (N.) magnoumbilicata.* These radiating sulci vary greatly in strength but in general decrease in prominence with age. Juvenile specimens of *"Natica" "(Naticarius)" semilunata* I. Lea, 1833 from the middle Claiborne may be superficially confused with *N. (N.) brevisulcata* but the lack of the umbilical rib in the latter will distinguish them. As Harris (1899, p.86–87) noted, some Sabine specimens of *"N." (N.) semilunata* lack the umbilical rib; this form is higher-spired, lacks the radiating sulci and the striae below the suture. Young individuals of these species however, can be very difficult to distinguish from one another.

Etymology.—The specific name is derived from *brevi*—(Latin, short), *sulcata* (Latin, folds).

Type information.—Holotype: PRI 30354; paratypes: PRI 30355, 30356. Type locality: locality 20.

Material examined.—45 specimens, the largest: 10 mm width, 10.5 mm in length.

Subgenus **CARINACCA** Marwick, 1924, p. 553

Type species.—Ampullina waihaoensis Suter, 1917, by original designation. Eocene of New Zealand.

Original diagnosis.–"Shell of moderate size, ovate, smooth, widely umbilicated; spire low; suture sometimes impressed but generally tangential; aperture semilunar; outer lip practically straight but strongly retracted to suture; inclined 25° to 30° from vertical; inner margin straight with a short, fairly thick parietal callus; umbilicus with an obsolete funicle on its long apertural margin (sometimes absent altogether), and bounded by a broad strong ridge formed by a prominent thickening of apertural margin at anterior corner." (Marwick, 1924, p. 553)

Remarks.—The subgenus is restricted to the Eocene.

Natica (Carinacca) moffitti, new species

Plate 12, figures 15–16

Description.—Shell small to medium in size, elongate-ovate. Whorls five, nucleus minute, protoconch of one-half whorl, more or less depressed. Whorls with deeply impressed and slightly channeled sutures, shoulder small, flat, and more visible in the earlier whorls. Surface smooth and polished with prosocline lines of growth and microscopic impressed irregular spiral lines most visible posteriorly; one larger line below the suture. Aperture oblique, semilunate, outer lip thick and anteriorly extended, the lip thickened and reflected forming a wide, sharply defined band that spirals into the umbilicus from the left hand margin. Inner lip straight to slightly excavated with a moderately thick deposit of callus, posteriorly margined by a weak channel. Umbilicus striated within and with a wide weak funicle in the posterior area, the end of which is covered over by a tongue of callus.

Remarks.—The combination of characters seen in these specimens makes them difficult to place generically within the Gulf Coast Tertiary. They most closely resemble *Natica (Naticarius) reversa* Whitfield, 1865 from the Naheola Formation of the Midway Group. That species, which is a higher-spired form, has an umbilicus covered more at the upper margin but does, however, possess a similar, although less sharply defined umbilical band and a weak funicle. At first sight the umbilical band and shouldered whorls might place it in *Ampullina s.s.* of the subfamily Globulariinae, but the presence of the funicle precludes that. The robust nature of the shell, flattened apex, apertural shape and funicle place it in the Naticinae, and with some hesitation it is placed in the subgenus *Carinacca,* so far restricted to the Eocene of New Zealand and one representative *Natica (Carinacca) rasensis* M. A. Hanna, 1927, from the Middle Eocene of California, La Jolla Group, Rosa Canyon, San Diego. Another similar, although more distantly related species is *Euspira marylandica* (Conrad, 1865a) from the Paleocene Aquia Formation and a variety from the Lower Eocene Tuscahoma Formation; this species possesses a small, weak funicle and shows the incipient development of a reflected outer lip.

Etymology.—The species is named after John Moffitt, geophysicist and trilobite expert.

Type information.—Holotype: PRI 30357; paratypes: PRI 30358, 30359. Type locality: locality 20.

Material examined.—108 specimens, the largest 10.6 mm in width, 11.0 mm in length.

Subfamily **POLINICINAE** Gray, 1847, p. 149[8]

Genus **POLINICES** Montfort, 1810, pp. 223–224, pl. 56

Type species.—Polinices albus Montfort, 1810, by original designation. Recent in the West Indies.

Diagnosis.—Shell small to large, globose to ovate, whorls inflated to flattened, smooth except for incremental growth lines and microscopic spiral costellae; suture slightly to deeply impressed. Umbilicus narrowly to broadly open, funicle weak to absent; umbilical callus slender and broad to massive; parietal callus thin or thick.

Remarks.—Polinices ranges from the Upper Cretaceous to Recent.

Subgenus **PLICONACCA** Cossmann and Martin, 1914, p. 171

Type species.—Polinices trisulcata Martin, 1914, by monotypy. Eocene of Java.

Diagnosis.—Shell ovate, low-spired. Protoconch with one and a half smooth moderately convex whorls; suture impressed, initially with short radiating folds which become obsolete on later whorls and exist there only as growth lines. Whorls convex or with a very slight subsutural depression. Aperture ovate, labrum thickened, no fold, umbilicus partially covered with a thick spread of callus upon which are three impressed grooves, the middle one the strongest, the anterior one also strong and the posterior usually indistinct (after Martin, 1914).

Remarks.—According to Wenz (1941, p. 1031) subgenus *Pliconacca* is restricted to the Eocene.

Polinices (Pliconacca) onustus reklawensis, new subspecies

Description.—Shell medium in size, obliquely ovate in profile. Whorls four and a half to five, nucleus minute, no visible demarcation between the protoconch and adult whorls. Suture finely impressed (more so in earlier whorls) by a line that is just visible under the microscope. Whorls shouldered, concave above and uniformly convex below. Aperture lunate, oblique, outer lip rounded. Inner lip covered with a thick callus covering most of the umbilicus and leaving just a slit. Surface of callus with one transverse groove ending at the upper entrance of the umbilicus and an obsolete parallel depression on either side of it. Umbilicus smooth within, or only showing lines of growth; rounded funicle present and covered with callus to its lower end.

Remarks.—The species is placed in *Polinices* by the character of the callus, the flatsided whorls, and the shape and inclination of the aperture. Incipient secondary callus grooves are sometimes visible, and the three grooves place it in section *Pliconacca*, although with some hesitation due to their obsolete nature. The species has strong affinities with both *Polinices (Pliconacca) onustus* (Whitfield, 1865) of the Midway group, and the higher spired form *P. (P.) onustus* in the Sabine; it would seem *P. (P.) onustus reklawensis* is the continuation of that line in the Reklaw which leads to *Polinices aratus* (Gabb, 1860) of the middle Claibornian. The species, however, is decidedly nearer *P. (P.) onustus*, to which it is referred as a subspecies.

Etymology.—Referring to the Reklaw Formation.

Type information.—Holotype: PRI 30360; paratypes: PRI 30361, 30362. Type locality: locality 20.

Material examined.—87 specimens, the largest 13.5 mm in length, 11.2 mm in width.

Subfamily **SININAE** Woodring, 1928, p. 387

Genus **SINUM** Roeding, 1798, p. 14

Type species.—Helix haliotoidea Linnaeus, 1758, by subsequent designation (Dall, 1915, p. 109). Recent off the coast of West Africa.

Diagnosis.—Shells small to large; whorls typically depressed, may be globose, rarely elongate; sculpture with distinct, closely spaced costellae. Umbilicus extremely narrow and slit-like or closed. Outer lip may be weakly crenulated.

Remarks.—Sinum is known from the Upper Cretaceous. It is primarily tropical in distribution.

Sinum taylori, new species

Plate 13, figures 3–4

Description.—Protoconch of two and a half to two and three-quarter smooth, erect whorls. Adult sculpture starts at an oblique angle, the line defining the transition being practically tangential to the suture of the preceding whorl. Sculpture of numerous longitudinal spiral flat-topped striae and wide interstices and sometimes one to two microscopic intermediate threads. Collabral sculpture of microscopic but distinct rounded spiral threads, sometimes crowded, the threads overriding the longitidinal striae, the two sets together forming a reticulated pattern. Aperture ovate, callus thin and reflected over the upper part of the umbilicus.

Remarks.—On the basis of the degree of flattening of the shell, the Eocene species of *Sinum* from the Gulf coastal plain can be arranged in the following sequence: *S. fiski* LeBlank, 1942, *S. bilix* (Conrad, 1833c), *S. declive* (Conrad, 1833b), and *S. arctatum* (Conrad, 1833b); *S. fiski* is from the Wilcox Group, the other three range from the Middle to the Upper Claiborne Within the above sequence both *Sinum taylori* and *Sinum moveum* (described next) would be placed between *S. declive* and *S. arctatum,* being however closer to *S. declive.* The sculpture of *S. taylori* is quite distinct, with its sharp raised lines and almost no intermediate striae in the interstices, *S. declive* has that arrangement almost reversed in having fine impressed lines and many intermediate striae. Both Reklaw species are additionally characterized by the near tangential transitional line separating the juvenile from adult shell. A similar pattern of sharp raised lines is also seen in *S. arctatum.*

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[8] *Nomen transl.* Kabat, 1991 (*ex* Finlay and Marwick, 1937, p. 53).

Etymology.—Referring to the type locality, Joe Taylor Branch.

Type information.—Holotype: PRI 30363; paratypes: PRI 30364–30366. Type locality: locality 20.

Material examined.—18 specimens, the largest 6.7 mm length, 7.0 mm height.

Sinum moveum, new species

Plate 13, figures 1–2

Description.—Shell elongate, oval, protoconch of three smooth erect rounded whorls, nucleus minute. Last protoconch whorl and first quarter adult whorl slightly depressed within the final body whorl. Suture deeply impressed. Adult stage of one and a quarter to one and a half whorls, surface granular, sculpture of close-set spiral striae and finer intermediate threads that appear wrinkled due to periodic lateral offsets at larger lines of growth. The effect is that the shell appears to possess curved longitudinal striations when viewed from some distance. Aperture obliquely ovate with a callus reflected and covering the right hand edge of the large ovate umbilicus.

Remarks.—Very similar in shape to *Sinum declive* (Conrad, 1833b) although the sculpture in that species consists of broader bands and the umbilicus is sublunate. From the shape alone *S. moveum* is additionally distinguished by possessing a broad shoulder carination, and another anterior to that on the body whorl. The juvenile to adult transition is intermediate in form to that in *S. declive* and *S. taylori.*

Etymology.—The name *moveum* (Latin, movement), refers to the wavy character of the spiral striae.

Type information.—Holotype: PRI 30367; paratype: PRI 30368. Type locality: locality 20.

Material examined.—19 specimens, the largest uncrushed specimen, 8.2 mm width, 8.1 mm height.

Superfamily **TONNOIDEA** Suter, 1913, p. 313

Family **CASSIDAE** Swainson, 1840, p. 89

Genus **GALEODEA** Link, 1806, p. 113

Type species.—Buccinum echinophorum Linnaeus, 1758, by monotypy. Recent in the Atlantic and Mediterranean.

Diagnosis.—Shell thin, with a moderately elevated spire, appressed suture and uniform spiral sculpture; sometimes more or less nodulous on the prominent spiral keels; with a conspicuous periostracum; the outer lip reflected and more or less transversely lirate, with a tendency to a more prominent denticle near the posterior angle and at the proximal end of the canal; inner lip with a broad callus, smooth or obscurely lirate, with margin more or less free in the adult; canal elongate and recurved, with just a trace of a siphonal fasciole; operculum subovate with the nucleus eccentric.

Remarks.—Galeodea is known from the Eocene onwards, recent in the Mediterranean.

Subgenus **MAMBRINA** Gardner, 1939, p. 23

Type species.—Type species.—*Cassidaria planotecta,* Meyer and Aldrich, 1886, by original designation. Cook Mountain Formation of Newton, Mississippi.

Diagnosis.—Shell medium in size to large. Protoconch naticoid, early whorls offset from the vertical axis by about 15°. Spire flat to moderately coleoconoidal, later whorls often encroaching over the earlier ones. Body whorl bicarinate, "box-like", the area between the carinae flat to concave, the carinae outlined by noded spirals, the remaining spiral sculpture usually fine and simple, only one varix and that a terminal one. Outer lip thickened, with a strong tooth anteriorly, and usually dentate along its entire length. Callus shield broad, flaring, detached below the lower keel; anterior canal, long, slender, produced in the plane of the aperture, but not in the axis of body and spire.

Remarks.—There is some confusion regarding the subgenera *Mambrina* and *Gomphopages,* Gardner designated *Cassidaria planotecta* Meyer and Aldrich, 1886 as type of *Mambrina* and included three species in the subgenus: *G. (M.) koureos* Gardner, 1939, *G. (M.)* sp. from the Wilcox Group of Mexico, and the type *G. (M.) planotecta* (Meyer and Aldrich, 1886). In the same publication she also defined subgenus *Gomphopages* with *Galeodea (G?) millsapsi* Sullivan and Gardner as the type. She first states the subgenus is only known from the holotype, but then on the next page questionably includes *G. (G?) millsapsi* in the same taxon. Three primary characters are used to characterize *Gomphopages*: the heavy chalky textured shell, the long slender anterior canal, and the prominent shoulder tubercles that are flattened in the plane of the axis and connected by low axial riblets to the basal series of nodes. On examination of the holotype it only appears as if the shell has a chalky texture, the texture probably due to weathering and damage during preparation; the shell was encased in a hard matrix and shows indications of having been badly prepared with hammer and chisel. The long anterior canal, and flattened shoulder tubercles are features of both the *Mambrina* and *Gomphopages* sections and so cannot be used in separation of the two. Specimens that can be assigned to *G. turneri* from the Weches Formation near Nacogdoches show a variable development of the axial riblets, some possess them weakly and others not at all. On balance then, the only consistent feature separating *Gomphopages* from *Mambrina* is the heavy shell and that also appears to be dependent on age, older larger specimens are generally heavier shelled. I believe, therefore, that *Gomphopages* is a synonym of *Mambrina, Mambrina* having page priority in Gardner's publication. Unfortunately Gardner's assignment of *G. koureos,* followed by MacNeil in MacNeil and Dockery, 1984, and the similar species from Mexico to *Mambrina,* is also in error. *G. koureos* and *Galeodea dubia* (Aldrich, 1885), which ranges from the Hatchetigbee Formation to the Weches Formation, clearly form a separate group which is characterized by a rounded body whorl with two to four spiral rows of nodes; a higher, often stepped spire; shows no sign of a long anterior canal; and often possesses more than one varix. Over 60 specimens of *G. dubia* were examined from the Weches Formation and not one showed any indication of a long anterior canal. Two Eocene European species which also appear to belong to this latter group are *Galeodea coronata* (Deshayes, 1830) and *"Cassis" striata* J. Sowerby, 1812. As noted by Palmer (1937, p. 253), G. D. Harris identified specimens of the Sabine species *Galeodea dubia* (Aldrich, 1885) from the Weches of Burleson Bluff, a range that would include the Reklaw era. I have verified the occurrence at Burleson Bluff and the same or a very similar species is common in Weches strata near Nacogdoches; no example of this species or anything similar has been discovered in the Reklaw deposits and in any case this species has little similarity to the ones discussed above.

Galeodea (Mambrina) turneri Gardner, 1939
Plate 14, figures 6–7

Galeodea (Gomphopages) turneri Gardner, 1939, p. 25, pl. 8, figs. 1, 4.

Original description.—"Shell of usual dimensions for the group, unusually heavy. Spire very low, the apex scarcely rising above the reverted lip at the posterior extremity of the aperture. Body whorl widely shouldered, deeply serrate at the periphery and serrate but less deeply at the second carina which outlines the base of the body. Inner lateral margin deeply and sharply constricted at the base of the body, the outer margin scarcely at all. Anterior canal horizontally compressed and turned sharply to the left and backward. A single nuclear whorl preserved. Four rapidly enlarging postnuclear whorls, the incised suture following the periphery and on the last whorl crenulated by the coronal spines. Entire surface spirally lirate, the lirae tending to alternate in strength and running about five primaries to each of the whorls of the spire and the shoulder of the body, finer and less regular upon the medial portion of the body, coarser toward the anterior fasciole. Axial sculpture developed only upon the final whorls. Peripheral spines very strong, laterally compressed, nine on the unique type, one of the nine partly concealed by the reverted outer lip; series at the base of the body less prominent, more conical than those on the periphery but in line with them. Incremental sculpture relatively strong, retractive upon the shoulder. Aperture narrow, obliquely lenticular, bent towards the apex and obtusely angulated posteriorly, obscurely angulated also at the periphery, compressed anteriorly into a slot-like opening. Apertural opening entirely surrounded by heavily callused margins. Outer lip very much thickened and reverted, with a suggestion of a *Cassis*-like flattening and, at the opening to the anterior canal, a suggestion of a constriction such as that upon *Strombus* for the extrusion of the eye stalks; reverted lip continuous around the posterior commissure, encroaching slightly on the preceding whorl and spread widely and heavily over the body whorl, but free from it between the base of the body and the anterior fasciole. Fasciole conspicuously wide and conspicuously compressed, oblique to the axis of the shell. Dimensions of holotype: Height, 43.0 millimetres; greatest diameter, 38.0 millimetres; diameter at right angles to the greatest diameter, 32.0 millimetres." (Gardner, 1939, p. 25)

Remarks.—Gardner's description of this species is very good but as she only had one worn specimen some additional remarks can be made. The protoconch is large and consists of three smooth rounded whorls; the nucleus is expanded and flattened; the protoconch and first half teleoconch whorl are offset by an angle of about 15° from the shell axis. Teleoconch whorls start with eight or nine spiral lines that after the first half whorl become crenulated; suture margined by a slightly concave ramp, the ramp delimited by two slightly stronger crenulated lines, the upper duplex, and a weaker medial one. The type has nine peripheral flattened spines but the number varies between seven and 12 with nine the most common number on large specimens. The very fine Reklaw specimen figured has a beautifully polished, almost glazed surface, the body whorl with effervescent spiral sculpture and prominent growth lines. Larger specimens often show irregular labial rugae which with increasing age migrate from within the aperture and thus become visible. Juvenile specimens of *G. (G.) turneri* are very difficult to distinguish from juvenile specimens of the cassid *Phalium (Semicassis) reklawensis* n.sp., their separation will be discussed further under that latter species' section. The number of large complete and fragmentary specimens of *G.* (*G.*) *turneri* shows this to have been one of the commonest large gastropods in the Reklaw seas; it is surprising only one specimen of this impressive species has previously been discovered.

Type information.—Holotype: USNM 495184. Type locality: USGS Sta. 13808, bend of Colorado River, 4.8 km (=3 miles) above old Burleson ferry. The exact location has been lost but from the description it appears to also be locality 8 (TBEG 11-T-72) which is in the Reklaw Formation, and not the Weches as given by Gardner. Figured Reklaw specimen from location 14.

Material examined.—The type, an additional six relatively complete individuals and 15 partial specimens. The largest, PRI 33125, that is figured is 63.5 mm length, 31.8 mm maximum diameter.

Genus **PHALIUM** Link, 1806, p. 112

Type species.—Buccinum glauca Linnaeus, 1758, by subsequent designation (Dall, 1909b, p. 62). Recent in the Indo-Pacific.

Diagnosis.—Shell medium in size; spire acuminate; last whorl well-rounded. Both the false and true umbilicus usually open. Parietal shield anteriorly well-developed; outer lip thick and with one row of denticles which may be produced into spines at the lower end.

Range.—The Cassidae are known from the Eocene onwards, and are carnivorous. Their main prey is reported to be sea urchins. The group is found predominantly in warmer waters although a few live in cooler latitudes.

Subgenus **SEMICASSIS** Mörch, 1852, p. 112

Type species.—Cassis bisulcata Schubert and Wagner, 1829, by subsequent designation (Harris, G. F., 1897, p. 198). East Africa to the Marshall Islands and Japan to Australia.

Diagnosis.—Shells somewhat globular, rarely with varices on the spire; outer surface usually with numerous spiral threads or incised lines. Columella shield finely wrinkled. Outer lip with fine denticles; base of outer lip smooth. Siphonal fasciole is rounded, showing a few longitudinal lines adaperturally.

Phalium (Semicassis) reklawensis, new species
Plate 13, figures 7–8

Description.—Shell small to medium sized, protoconch of three and a half smooth globular whorls, the first minute and flattened. Adult sculpture begins sharply with six to nine spiral revolving lines and equal sized longitudinal ribs that become obsolete after one whorl. Spire whorls shouldered, with one large spiral line on the carina and another large one below. In older specimens the ribs on and below the carina develop many small pointed nodes.The interstitial area between the spiral lines usually with one to three, sometimes many interstitial threads. Over the later whorls the sculpture consists of thick revolving ribs, rarely with smaller lines, the interstitial spaces with spiral threads; the whole crossed by numerous close-set striae, the intersections of the two being slightly nodular. Outer lip prominently thickened, the edge sharp, and with 11 to 12 small linear teeth and one larger one underneath the suture at the posterior end. Columellar shield with large wrinkles, regular above, irregular below and within the lower portion of the aperture. Small umbilicus present but covered by the columellar shield. Siphonal fasciole longitudinally threaded. Larger specimens have the body whorl slightly bicarinate, the lower carina defined by a thickened, sometimes nodular line.

Remarks.—Over 40 complete juvenile and near-adult specimens show this to be a relatively common species in the Reklaw. One large fragment indicates the species reached perhaps 30 mm in length, indicating that all complete specimens may be to some extent juvenile. The early whorls of this species are quite difficult to separate from *Galeodea (Gomphopages) turneri* Gardner, 1939; without the protoconch one could note *G. (S.) reklawensis* has spiral lines of differing strengths, sharper longitudinal ribbing, and beading at their intersections with the spiral sculpture. A specimen from St. Maurice, Louisiana in the Academy of Natural Sciences in Philadelphia labelled *Galeodea planotecta* (missing the outer lip) has similar but not quite so coarse an ornamentation and no longitudinal ribbing on the spire. Large fragments of the body whorl of this species show mature individuals becoming bicarinate, and then tricarinate in shape. The absence of varices on the spire, the wrinkled columellar shield and the longitudinally threaded siphonal fasciole place the species in *Semicassis.* The earliest *Semicassis* so far reported is from the Oligocene of Oregon, Washington, and the Indo-Pacific region. The Cook Mountain Formation species *Phalium brevicostatum* (Conrad, 1834) is easily separated from *P. (S.) reklawensis* by its more elongate shape and ornamentation of flat spiral ribbons and incised grooves. The Weches formation furnishes a *Phalium* sp. with characters midway between the Cook Mountain and Reklaw species. A species with a similar sculpture, but somewhat less related is *Phalium (Semicassis) caela-*

tura (Conrad, 1848b), from the Lower Oligocene, Vicksburg Group. This species is more elongated, has a very weak shoulder, a rounded outer lip, and possesses a deep, strongly bent back, anterior notch rather than the short, almost unnotched, canal seen in *P. (S.) reklawensis.*

Etymology.—Noting the Reklaw Formation where the species occurs.

Type information.—Holotype: PRI 30373. Type locality: locality 8. Paratype: UT-TMM 3581, locality 10.

Material examined.—40 specimens, the largest of which (the holotype) is 20 mm in length.

Family **FICIDAE** Meek, 1864, p. 32

Genus **FICOPSIS** Conrad, 1866b, p. 100

Type species.—Hemifusus remondii Gabb, 1864, by subsequent designation (Stewart, 1927, p. 375). Martinez Eocene of California.

Diagnosis.—Shell more or less inflated, with a low spire and a long beak; sculpture usually cancellate or with crenulated spirals; aperture elongate with a long and twisted siphonal canal.

Remarks.—This genus is restricted to the Eocene of Europe and North America.

Ficopsis nucleoides, new species

Plate 14, figures 3–5

Description.—Shell small, whorls six, protoconch consists of three and a quarter to three and a half smooth whorls of which the last quarter to one-half whorl may show faint curving irregular striae on the abapical half. The first half whorl is in line with the shell axis while the rest of the protoconch is at an acute angle of 20° to 30°. The adult sculpture consists of a cancellate ornament of longitudinal and spiral lirae, the spiral lines crossing over the longitudinal ones. On the beak the longitudinal lirae are weaker and the spiral ones alternate in size. Generally one varix occurs on the first adult whorl, and in older specimens also on the body whorl. The body whorl is bicarinate with four to seven spiral lines on the shoulder which tend to alternate in size. Labrum sharp and in some specimens thickened within.

Remarks.—The longitudinal costae on several specimens are so prominent that they could almost be regarded as costae. The medial carination of the body whorl is another relatively variable character, strong in some specimens and almost obsolete in others. The species combines the larger nucleus, greater number of lines on the shoulder and the carinate body whorl of *Ficopsis penita* (Conrad, 1833a) that ranges from the Weches Formation to the Gosport Sand Formation, with the obtuse apex, varices and the tendency to form longitudinal folds of *Ficopsis texana* (Harris, 1895a), known from the Cook Mountain Formation of Texas and the McBean Formation of South Carolina; it is probably ancestral to both. The larger flattened protoconch is the primary character differentiating these specimens from *F. penita* and *F. texana.*

Etymology.—The specific name *nucleoides* (Latin, nucleus) refers to the large inflated nucleus.

Type information.—Cotypes: PRI 30374–30375; paratypes: PRI 30376, 30377. Type locality: locality 20.

Material examined.—109 specimens, the largest complete one: 10.2 mm length, 5.1 mm width.

Suborder **PTENOGLOSSA** Gray, 1853b, p. 129

Superfamily **TRIPHOROIDEA** Gray, 1847a, p. 154[9]

Family **CERITHIOPSIDAE** H. and A. Adams, 1853, p. 239

Subfamily **CERITHIOPSIINAE** H. and A. Adams, 1853, p. 239[10]

Genus **CERITHIOPSIS** Forbes and Hanley, 1851, p. 364

Type species.—Murex tubercularis Montague, 1803, by monotypy. Recent in European Seas.

Diagnosis.—Shell small, slender, turrited, protoconch whorls smooth, axially ribbed, longitudinally lirate or a combination of the above. Adult whorls ornamented with tuberculated or beaded spiral cords. Aperture oval or rounded rectangular in shape, columella short, slightly twisted.

Remarks.—The genus is known from the Upper Cretaceous to Recent. The animals are all marine and reported to feed on sponges.

Subgenus **CERITHIOPSINA** Bartsch, 1911, p. 328

Type species.—Cerithiopsis (Cerithiopsis) necropolitana Bartsch, 1911, by original designation. Pleistocene of the San Pedro Group, Deadmans Island, California.

Diagnosis.—Differs from *Cerithiopsis* s.s. by having the initial portion of the protoconch whorls smooth and the final portion axially ribbed.

Remarks.—The subgenus ranges from the Eocene to Plio-Pleistocene.

Cerithiopsis (Cerithiopsina?) sp.

Plate 12, figures 8–9

Description.—Shell very small, slender, of nine whorls. Protoconch "*Gemmula* like", of five whorls, the tip partially immersed; the first whorl smooth and the remaining ones with increasingly protractive riblets. Transition to teleoconch sharp and angular. Adult whorls with concave ramp and three spiral lines on the ramp, the lines crossing over sharp longitudinal folds that die out before reaching the suture. Body whorl with six spiral lines, the fourth from the suture the largest and the anterior two the weakest. Outer lip sharp, aperture oval, columella slightly thickened. No anterior canal or spout.

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[9] *Nomen transl.* Kosuge, 1966.

[10] *Nomen transl.* (*ex* subfamily Adams, H. and Adams, A, 1853, p. 223, not 1854 of authors).

Remarks.—It is conceivable this small shell is the juvenile of *Bittium ridgei* n. sp., due to some similarity in the early whorls, but the present collections of *B. ridgei* show so little variation that this seems unlikely. Were the protoconch absent there might be little hesitation in assigning the specimen to *Bittium s.l.,* but the multiwhorled ornamented protoconch precludes that. A monotypic recent genus with similar sculpture is *Eumetula* Thiele, 1912, from the Antarctic; this genus has a thickly ribbed protoconch whorl, a similar whorl profile and similar teleoconch sculpture with two spiral lines. Another species in which the teleoconch sculpture is markedly similar is *Cerithiella dertobcarinata* Sacco, 1895, from the Miocene (Tortonian) of Italy, of which the protoconch is unknown.

Figured specimen: PRI 30378, from locality 4.

Material examined.—One specimen 2.0 mm in length.

Superfamily **JANTHINOIDEA** Lamarck, 1812, p. 204

Family **EPITONIIDAE** Suter, 1913, p. 318[11]

Genus **AMAEA** H. and A. Adams, 1853, p. 223[12]

Type species.—Scalaris magnifica Sowerby, 1844a, by subsequent designation (de Boury, 1909, p. 258). Recent from the Pacific Coast of Japan.

Diagnosis.—Shell high, thin, shining; whorls inflated, with numerous longitudinal and spiral lines or threads, sometimes with a few thin irregular varices; basal disc defined by a prominent line; aperture ovate to quadrate.

Remarks.—The genus is known from the Cretaceous to Recent.

Subgenus **SCALINA** Conrad, 1865a, p. 27

Type species.—Scalaria staminea Conrad, 1860, by subsequent designation (Palmer, 1937, p. 102). Eocene, Gosport Sand Formation of Alabama.

Diagnosis.—Whorls regularly rounded; whorls reticulated with axial costae and spiral ridges, the axials finer and less crowded together than the spirals, the interstices of the spirals with fine linear grooves. Basal disc conspicuous and with fine cancellate ornament.

Remarks.—Modern representatives live in deep water. The genus ranges from the Eocene to Recent.

Amaea (Scalina) macula, new species

Plate 12, figures 1–2

Description.—Shell high, turrited, with at least three smooth and rounded nuclear whorls. Adult whorls covered with numerous lamellose costae which cross over six to seven broad, rounded spiral lines, curve forward and become almost tangential at the posterior suture, and then finally disappear beneath the preceding whorl. Whorls slightly shouldered, the shoulder free of spiral lines. Basal disc present and margined by a strong nodular revolving cord, the nodules appearing where the ribs cross over the cord. The ribs continue to the obscure fasciole as rounded lamellae, where they then bunch up and become a fringe at the peristome. Aperture oval with the lower margin slightly reflected; outer lip not thickened. The body whorl of a complete specimen with 38 ribs, a larger broken specimen with 48 ribs on the body whorl.

Remarks.—The bent axial ribs, spiral sculpture, lack of varices and the basal disc with the close-set spiral and radial lines place this species in *Scalina.* The closest species is *Amaea (Scalina) staminea* (Conrad, 1860) from the Gosport Sand Formation; that species has a similar rounded whorl profile, axial ribs which meet the posterior suture at an acute angle, and a weak cord margining the basal disc, the disc itself being almost smooth. More distantly related are Amaea (*Scalina) trapaquara* (Harris, 1895a) and *Amaea (Scalina) trapaquara engonata* (Harris, 1895a) from the Cook Mountain and Weches formations respectively; these two species have a fairly prominent concave upper whorl profile, axial ribs that meet the suture almost at right angles, and no cord margining the basal disc. Perhaps the commonest species of Epitoniidae from the Gulf Coast Eocene is *Cirsotrema (Coroniscala) nassulum* (Conrad, 1833a), to which it bears a general, although superficial resemblance; that species has almost no macro spiral sculpture.

Etymology.—the name *macula* (Latin, mesh), refers to the pattern generated by the equally sized spiral and longitudinal lines.

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[11] Many authors incorrectly ascribe the family name Epitoniidae to Berry (1910), probably a mistake for de Boury (1910). In that paper de Boury does discuss Dall's use of the genus *Epitonium* instead of *Scala* in connection with the validity of the Bolton catalogue, but was not in favour of using it. Dall apparently first uses the genus *Epitonium* instead of *Scala* in Dall (1909b, p. 52), after a discussion some years earlier (Dall, 1889b, pp. 315–317). The first author to actually use the family name Epitoniidae seems to be Suter (1913).

[12] *Nomen transl.* (*ex* family Adams, H. and Adams, A, 1853, not 1854 of authors).

Type information.—Holotype: PRI 30350; paratype: PRI 30351. Type locality: locality 20.

Material examined.—79 specimens, the largest complete 12.0 mm in length.

Subgenus **FORATISCALA** de Boury, 1887a, p. 28

Type species.—Scalaria cerithiformis Watelet, 1853, by original designation. Eocene (Cuisian) of Hérouval, France.

Diagnosis.—Shell small, narrow and thin-shelled. Whorls inflated, with deeply impressed sutures, ornamented with longitudinal lamellar ribs and revolving axial lines of similar strength. Basal disc present, separated from the body whorl and the wide umbilicus by strong cords. Aperture oblique, not entire, outer lip thin.

Remarks.—The presence of the umbilicus distinguishes this taxon from other similar ones. The genus is known from the Paleocene to Eocene.

Amaea (Foratiscala) texana, new species

Plate 12, figures 3–4

Description.—Shell small, whorls at least eight, tip of spire worn. Whorls rounded, very slightly shouldered and ornamented by five spiral lines and numerous longitudinal lines, the shoulder free of spiral lines. Basal disc present, margined by a strong cord, the disc with weak spiral lines and weaker longitudinal ones, these are the continuation of the longitudinal lines ornamenting the whorls and continue into the umbilical area as fine lamellae. The posterior part of the umbilicus with a thin covering of callus that spreads over the upper part of the basal disc.

Remarks.—Even though this specimen is a little worn, it appears to be closely related to *Amaea (Scalina) macula* from the Reklaw Formation. *A. (F.) texana* has the same number of spiral lines, a similar whorl profile with only a slightly more prominent shoulder, and stronger spiral than longitudinal lines. It is the character of the basal disc, however, where the differences are greater, in *A. (S.) macula* the longitudinal lines end in a "frill" against the columella whereas here they run into the umbilicus without bunching up. The similarity of the spire to *A. (S.) macula* could be taken as variation within a species living in different environments, as *A. (S.) macula* is found in a clay/shale (lagoonal) matrix while *A. (F.) texana* was collected from an indurated sandstone/ironstone layer, which is taken as representing clearer waters and a near-shore higher energy environment. Species of the subgenus *Foratiscala* are relatively rare; Cossmann and Pissaro (1910–1913, pl. 8), list four species from the Paris Basin Tertiary ranging from the Cuisian to the Bartonian. Wenz (1944) notes Recent species in the Indo-Pacific. The present species is allied to *Amaea (Foratiscala) sculptata* (Deshayes, 1861), apparently from the Cuisian, although this may be a mistake as Furon and Soyer (1947) do not include it under the Cuisian in their lists. This appears to be the first record of this subgenus in the Americas.

Etymology.—Referring to the discovery in Texas.

Type information.—Holotype: PRI 30352. Type locality: locality 7.

Material examined.—One specimen, 10.7 mm in length, 3.6 mm maximum diameter.

Genus **RUGATISCALA** de Boury, 1913, p. 72

Type species.—Scalaria levesquei de Boury, 1887b, by original designation. Eocene (Cuisian) of the Paris Basin, France.

Original diagnosis.—"Testa solida, imperforata, eleongoturrita, costis longitudinalibus crassis et fimiculis transversis incrassatis ornati. Sutura mediocriter profunda. Anfractibus convexi, costis longitundinalibus crassis funiculis incrassatis impressi et nullo modo punctati. Ult anfra. spira minor, disco praditus. Apertura subrotunda. Peritoma duples. Internum continuum crassiusculum, vix prominulum, nitidum. Externum, postice interruptum, crassum et altema varice costitutum." (de Boury, 1913, p. 72)

Free translation.—Shell solid, not umbilicated; whorls inflated with bent axial ribs and (non-punctate) spiral lines; suture impressed. Basal disc concave, weakly spirally striate. Aperture oval, outer lip duplex, apertural varix present.

Remarks.—The genus ranges from the Eocene to the Miocene.

Rugatiscala cooperi, new species

Plate 12, figure 6–7

Description.—Shell small, tip of protoconch missing, three finely ribbed whorls remaining, the ribs feebly arcuate and continuous. Teleoconch with eight and a half whorls. Whorls with rounded longitudinal costae, 15 on the last whorl, the entire area crossed by five low rounded ribs that are larger medially and also more pronounced between the costae. Surface with an opalescent sheen, not punctate. Basal disc present, margined by a flat ribbon and with ten close-set spiral lines, the profile slightly concave with feeble radial undulations corresponding in position to the costae. Aperture ovate, peristome continuous, abaperturally duplex and slightly produced; minute umbilical slit present.

Remarks.—This species might be placed in *Rudiscala* (de Boury, 1909), due to the similarity to *Rudiscala harrisi*, Palmer, 1937 from the Lower Eocene Hatchetigbee Formation, and *Rudiscala sessilis* (Conrad, 1833b) from the Gosport Sand Formation; *R. harrisi* has the same number of ribs and the same minute crowded spiral sculpture. *R. harrisi* however, has an umbilical chink, lacks any larger spiral lines, and has a smooth multi-whorled protoconch quite unlike that of *R. cooperi.* The radically different protoconch in itself points at *R. cooperi* belonging to a different genus than *R. harrisi* and *R. sessilis* although the generally similar teleoconch sculpture is confusing. Cossmann, (1912, p 80) includes *Rudiscala* under *Turriscala* de Boury, 1890; Wenz (1940, pp. 792–793) places *Rudiscala* in synonymy with *Turriscala* and also includes *Rugatiscala* under the latter. Palmer (1937, p. 108) cites de Boury's review of *Turriscala* and *Rudiscala* where the differences are noted and gives *Rudiscala* full generic rank. For the same reasons I also prefer to give *Rugatiscala* full generic rank.

Etymology.—Named in honor of John Cooper of the Natural History Museum, London

Type information.—Holotype: PRI 30353. Type locality: locality 4.

Material examined.—One specimen, 5.4 mm in length.

Rugatiscala? sp.

Remarks.—One incomplete specimen was found of this species. There are seven and one-half remaining whorls; the nuclear whorls and half the body whorl are missing. The whorls are ornamented with strong, fairly sharp-topped axial ribs, 16 on the final whorl, all overriden by 17–20 spiral lines, those nearer the suture more crowded together. The basal disc is concave, and covered with spiral lines the one nearest the periphery about twice the size of the others. This species is distinguished from *Rugatiscala cooperi* n. sp. by the more numerous spiral lines and axial ribs, and the lack of an opalescent surface sheen. A similar species is *Rudiscala harrisi* Palmer, 1937 from the lower Eocene, Hatchetigbee Formation; this species is more elongate, has spiral lines of a punctate character, and a slight groove in the umbilical region. Two characters that are diagnostic of *Rugatiscala* are the terminal varix on the outer lip and the duplex character of the peristome at the columella. As both these characters cannot be seen due to the damage, the species is only doubtfully referred to this genus.

Type information.—Figured specimen: PRI 33124, 5.1 mm length.

Superfamily **EULIMOIDEA** H. and A. Adams, 1854, p. 235

Family **EULIMIDAE** Troschel, 1853, p. 112

Genus **MELANELLA** Bowdich, 1822, p. 27

Type species.—Melanella dufresnii Bowdich, 1822, by monotypy. Recent in the Indo-Pacific region.

Diagnosis.—Shell white, polished; last whorl produced, inner lip appressed for at least the greater part of the attenuated base; shell straight or flexed.

Remarks.—MacNeil and Dockery (1984), may be consulted for a discussion on the validity of *Melanella.* The animals are carnivorous, believed to be always associated with echinoderms. The genus ranges from the Upper Cretaceous to Recent.

Melanella minutissima, new species

Plate 23, figures 20–21

Description.—Shell minute, whorls six. Protoconch of one whorl merging smoothly into the adult whorls. First three to four adult whorls moderately convex with impressed sutures, thereafter almost flat, with a slight subsutural depression and flat and indistinct sutures. Aperture tear-drop shaped, outer lip thin and parasigmoidal, the maximum width occurring where the body whorl begins to curve towards the base. Columella slightly twisted and oblique.

Remarks.—This might be taken as the juvenile of the next species but the initial rounded whorls and parasigmoidal outer lip will separate the two species. The type of outer lip is similar to that exhibited by *Rissoina* d'Orbigny, 1840a, of which a Claibornian representative is *Rissoina (Leanella) cossmanni* (Aldrich, 1910b). The present species lacks the thickened outer lip and channeled sutures of that species. The Reklaw species combines characters of both *Melanella* and *Leanella* Cossmann, 1921, two taxa presently placed in different families. The rounded initial whorls and the impressed sutures of *M. minutissima* separate it from other Claibornian and Jacksonian species of the genus.

Etymology.—Noting the minute size of the species.

Type information.—Holotype: PRI 30546; paratype: PRI 30547. Type locality: locality 20.

Material examined.—Seven specimens, the largest 1.5 mm length.

Melanella cf. notata (I. Lea, 1833)

Plate 23, figures 22–24

Pasithea notata I. Lea, 1833, p. 101, pl. 4, fig. 80; H. C. Lea, 1849, p. 103; Harris, 1895c, p. 30.

Cf. *Pasithea lugubris* I. Lea, 1833, p. 101, pl. 4, fig. 81; H. C. Lea, 1849, p. 103; Harris, 1895c, p. 26.

Pyramis notata (I. Lea). Conrad *in* Morton, 1834, p. 4.

Eulima notata (I. Lea). Conrad, 1865a, p. 29; 1866a, p. 14; de Gregorio, 1890, p. 162, pl. 16, fig. 6, copy I. Lea.

Cf. *Eulima lugubris* (I. Lea). Conrad, 1865a, p. 29; 1866a, p. 14; Meyer, 1887b, p. 54, pl. 3, fig. 8; de Gregorio, 1890, p. 161, pl. 16, fig. 5a copy Meyer, fig. 5b copy I. Lea; Cossmann, 1893, p. 24, pl. 2, fig. 3; 1921, p. 193.

? *Turbonilla lugubris* (I. Lea). Dall, 1892, p. 255.

Not *Rissoina notata* (I. Lea). Cossmann, 1893, p. 27, pl. 1, fig. 34 = *Eulima cossmanni* Aldrich, 1910.

Not *Rissoina (Leaella) notata* (I. Lea), Cossmann, 1921, p. 91, pl. 3, figs. 59, 60 = *Eulima cossmanni* Aldrich, 1910.

Melanella notata (I. Lea). Palmer, 1937, p. 61, pl. 6, figs. 20, 26–30; pl. 79, fig. 1 type; Brann and Kent, 1960, p. 541; Glibert, 1962b, p. 257.

Balcis notata (I. Lea). Palmer and Brann, 1966, p. 523; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, p. 28, 30.

Original description.—"Shell subulate, highly polished; substance of the shell rather thick; apex acute; suture very small; whorls eleven, very flat, each one being marked with an impressed oblique line of growth; mouth small, acutely angular above, about one-fifth the length of the shell; columella somewhat thickened at the base; outer lip somewhat arched, with an obtuse edge." (Lea, 1833, p. 101)

Remarks.—The species is smaller and slightly slenderer than *Melanella notata* s.s. from the Gosport Sand Formation, but otherwise similar. It shows well the impressed line of growth on each whorl. Two well-preserved specimens have a glassy lustre and show the sutural area as a light colored band.

Type information.—Holotype: ANSP 5495. Figured Reklaw specimen: PRI 33105, from locality 14.

Material examined.—15 specimens, the largest (crushed) 8 mm length.

Melanella aff. **extremis** (Aldrich, 1911)
Plate 23, figure 19

Eulima extremis Aldrich, 1911, p. 8, pl. 3, fig.4; Palmer and Brann, 1966, p. 667.

Melanella extremis (Aldrich). Palmer, 1937, p. 65, pl. 6, figs. cf. 8, 9, 13 copy Aldrich, cf. 14, 15, cf. 21; Brann and Kent, 1960, p. 540.

Original description.—"Shell polished; whorls nine or ten; suture very shallow showing indistinctly; aperture elongate; outer lip slightly sinuous; inner lip reflected over the lower part of the pillar." (Aldrich, 1911, p. 8)

Remarks.—One crushed specimen was obtained of a very slender *Melanella* with the same shining polished surface seen in *M. extremis*, from the Middle Eocene.

Type information.–Holotype: USNM 1963 (lost *fide* Palmer and Brann, 1966, p. 667). Figured specimen: PRI 30417, 8.2 mm length, from locality 20.

Order **NEOGASTROPODA** Wenz, 1938, p. 71[13]

Superfamily **MURICIOIDEA** da Costa, 1776, p. 224

Family **MURICIDAE** da Costa, 1776, p. 224

Subfamily **MURICINAE** Rafinesque, 1815, p. 18

Genus **HEXAPLEX** Perry, 1811, pl. 8, fig. 4

Type species.—*Murex chichoreum* Gmelin, 1791, by subsequent designation (Iredale, 1915, p. 471). Recent, the Philippines.

Diagnosis.—Shell solid, usually quite large. Spire moderate to high, whorls with five or more spinose, foliated or knobbly varices and having spiral cords. Aperture large and ovate, canal short, recurved and partially obscured.

Remarks.—*Hexaplex* is similar to *Chicoreus* Montfort, 1810, except for the number of varices. Vokes (1968 pp. 86–87) gives a discussion particularly applicable to Tertiary members of the group. The distribution is principally tropical and subtropical in extent and in depths of 0 to 300 meters. The genus is known from the Eocene onward.

Hexaplex eoa, new species
Plate 14, figures 8–9

Description.—Shell small, high spired. Protoconch missing in all available specimens. Whorls at least six, rounded and with a flat to slightly convex prominent ramp; below the ramp with two or three spiral cords, the uppermost on the carina and almost effaced except on the varix. Body whorl with about 11 large cords becoming less prominent on the beak. Between the cords the surface shows numerous irregular spiral striae, stronger on the ramp, and an occasional intermediate spiral line. Early whorls with eight to nine foliated spinose varices, later whorls with 10 to 11; the tips of the spines strongly retractive. Aperture elliptical, outer lip with an open channel extending to a large spine; five prominent denticles below the spine, columella lip smooth, siphonal canal moderate in length.

Remarks.—This species belongs to the Claibornian group consisting of *Hexaplex (Hexaplex) texanus* Vokes, 1968, *Hexaplex (Hexaplex) silvaticus* (Palmer, 1937) and *Hexaplex (Hexaplex) vanuxemi* (Conrad, 1834). The present species is closest to the Weches species *H. (H.) texanus* and may be distinguished from it by the higher spire, the weaker posterior spiral cord and the lack of columella denticles. Both specimens are rather worn and were found embedded in extremely fossiliferous ironstone boulders occurring at the very top of the Marquez Member, the deposition of which is presumed to have been a near-shore environment. Despite the wear it can be seen that *H. (H.) eoa* is more prominently spinose that the other three species. This appears to be the oldest species of *Hexaplex* known within the limits of the genus as defined by Vokes, 1968, extending the the limits of the genus into the Reklaw.

Etymology.—The name *eoa* (Latin, dawn), refers to the dawn of the genus.

Type information.—Holotype: PRI 30381; paratype: PRI 30382. Type locality: locality 7.

Material examined.—Two specimens, the largest (the holotype) 15.0 mm in length.

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[13] Replacement name for Stenoglossa Bouvier, 1887.

Genus **PTERYNOTUS** Swainson, 1833, pl. 100

Type species.—Murex pinnatus Swainson, 1822, by subsequent designation (Swainson, 1822 pl. 122). Recent in the Indo-Pacific.

Diagnosis.—Small fusiform shells with three winged varices, siphonal canal usually open, columella lip adherent and smooth, spiral lines usually present.

Remarks.—Few modern members are known of this genus and those usually live in deep water. The group existed from the Early Paleocene and was relatively common especially in the Tertiary of the London and Paris Basins.

Subgenus **PTERYNOTUS** s.s.

Diagnosis.—Outer lip entire and without denticles, siphonal canal slender, open and recurved.

Pterynotus (Pterynotus) cf. **stenzeli** Vokes, 1970
Plate 14, figures 11–12

Pterynotus (Pterynotus) stenzeli Vokes, 1970, p. 8, pl. 1 fig. 5, 1992, p. 5, pl. 1, fig. 3; Harasewych and Jensen, 1979, no. 22, p. 3.

Remarks.—One specimen obtained of this species. The shell is unfortunately missing the outer lip, and without the presence of labral denticles and an open apertural spine cannot definitely be assigned to *P. (P.) stenzeli*; previous varix growth stages, however, show indications of the presence of such earlier spines. At six and a half whorls and 12.3 mm in length, the shell is smaller and slightly shorter than the typical Weches form, but this is not considered important enough for taxonomic separation. It does also appear that previous spines occurred above the carina unlike in *P. (P.) stenzeli* where they are positioned on the carina; if better specimens should validate this fact, the Reklaw forms may have to be separated.

Type information.—Holotype: TBEG 36637. Type locality: TBEG 173-T-19, 6.4 km west of Chireno; hill on San Augustine road (Texas Highway 21), Nacogdoches County, Texas. Figured Reklaw specimen: PRI 33126, from locality 4.

Superfamily **BUCCINOIDEA** Rafinesque, 1815, p. 145

Family **COLUMBELLIDAE** Swainson, 1840, p. 61

Genus **MITRELLA** Risso, 1826, p. 272

Type species.—Mitrella marmin Risso, 1826, by original designation. Recent in the Mediterranean.

Diagnosis.—Shell medium-sized, moderately slender, spire high, pillar slightly constricted. Nucleus slender, consisting of about one and a half bulging whorls, the first part rather loosely coiled. Aperture relatively wide. Anterior canal virtually absent, the outer lip extending down to base of aperture without any constriction. Siphonal notch shallow. Columella slightly bulging at base. Inner lip bearing slender denticles. Parietal callus thin except at posterior channel. Outer lip somewhat varicose, bearing a very shallow broad notch near suture, the interior bearing heavy denticles. Sculpture limited to weak spiral cords on pillar (Woodring, 1928, p. 273).

Remarks.—Nine species are found in the Paleogene of the Gulf costal plain. The group expanded greatly in Miocene times, with Gardner (1947) noting 22 species in the Alum Bluff Group of Florida. Abbott (1974) records 23 species from the Atlantic and Gulf coast provinces of the U.S. The genus is widely distributed today in warm and shallow waters.

Subgenus **CLINURELLA** Sacco, 1890, p. 44

Type species.—Columbella (Clinurella) scalaris Sacco, 1890, by subsequent designation (Palmer, 1937, p. 281). Miocene of Italy.

Diagnosis.—Shell small, turrited, spire high with an acute apex. Spire whorls smooth, straight-sided, sometimes with a subsutural spiral line. Body whorl with a few spiral lines on the base. Canal short, wide and somewhat off-center. Columella excavated, smooth; labrum crenulated or with short lirae.

Mitrella (Clinurella) nuttalli, new species
Plate 14, figures 15–17

Description.—Apical area of the larger specimens somewhat eroded. Juvenile specimens show a high conical protoconch of four and three-quarter whorls, the first two and one-half smooth, the next one and a quarter with close-set longitudinal threads that are bounded at the abapical suture by a spiral thread. Adult sculpture begins sharply and consists of smooth, straight-sided whorls with two equally sized threads below the suture and a groove of the same size above the suture. On large specimens the number of revolving lines may increase to four by the penultimate whorl; the body whorl lirate from the subsutural line to the base, the lines alternating in size. Outer lip crenate with five to nine lirae. Columella concave above, sometimes with a swelling on the lower margin; below reflected and moderately twisted.

Remarks.—This species has affinities to both *Mitrella (Clinurella) bucciniformis* (Heilprin, 1879) and *Mitrella (Columbellopsis) mississippiensis* (Meyer and Aldrich, 1886), both from the Upper Claiborne Group; *M. (C.) mississippiensis* has a smaller smooth area on the body whorl, a shorter canal, three tubercles on the columella and seven denticles on the labrum (not lirate as in *M. (C.) nuttalli*); *M. (C.) bucciniformis* has more prominently convex whorls, only one subsutural line on the later spire whorls, a larger smooth area on the body whorl and no twist to the canal. The crenate labrum and smooth inner lip place *M. (C.) nuttalli* in subgenus *Clinurella.*

Etymology.—Named in honor of Clive P. Nuttall formerly of the Natural History Museum, London.

Type information.—Holotype: PRI 30383; paratype: PRI 30384, a juvenile. Type locality: locality 20.

Material examined.—18 specimens, the largest: 9.5 mm length, 4.7 mm width.

Mitrella (Clinurella) nuttalli lineata,
new subspecies
Plate 14, figures 1–2

Description.—Shell small, thick shelled, to six and three-quarter whorls. Protoconch of three and a half whorls, usually all smooth, sometimes the final eighth with widely spaced indistinct riblets. Adult whorls convex, sutures impressed and in the center of a prominent channel. The whorls of the spire have a sculpture of flat-topped spiral bands, the bands wider than the interstices. Early whorls with one or two bands below the suture and by the fifth whorl the number of bands has increased to five. The body whorl with 15 main spiral bands, alternating with an equal number of smaller ones, becoming subequal in size towards the anterior end. Lines of growth very weak and parasigmoidal. Aperture elongate-elliptical, slightly more than half the total length of the shell, notched posteriorly and with a straight channel below. Outer lip worn, but apparently was thin-edged, labrum with ten strong lirae starting some distance behind the outer edge. Columella excavated above, the margin to the channel with a thick deposit of callus and one small denticle at the posterior end. Umbilical depression beside the large siphonal fasciole.

Remarks.—The different protoconch will separate this subspecies from *Mitrella nuttalli* immediately, without it the shorter form, thicker shell and more evenly lirate sculpture can be used. This species is close to *Mitrella alabamensis* (Aldrich, 1895) from the Hatchetigbee Formation of Alabama. The Alabama specimen is a thinner shelled and slenderer species, has denticles on the outer lip, a greater number of revolving lines on the spire and a more pronounced curvature of the outer lip. This specimen has only one swelling at the lower end of the parietal area. The specimen combines characters of both *Mitrella* s.s and *Astyris* s.s. The species of genus *Mitrella* are generally smooth except for the base of the last whorl and possesses a smooth or slightly wrinkled columella, while *Astyris* possesses a channeled suture and a body whorl equal to half of the total length. This species, *M. alabamensis* and a so far unnamed species from the Weches Formation at Burleson Bluff, Brazos River, Texas, form a natural group, and could belong to a new genus but without a specimen with an intact protoconch it is considered premature to define it here.

Etymology.—The specific name *lineata* (Latin, line), refers to the very prominent spiral lines over the entire surface.

Type information.—Holotype: PRI 30385. Type locality: locality 20.

Material examined.—21 specimens, the largest (the holotype), 13.0 mm length, 6.4 mm width.

Genus **METULA** H. and A. Adams, 1853, p. 84

Type species.—Buccinum metula Hinds, 1845 (cited by H. and A. Adams as *Metula hindsii*) by tautonomy. Recent, Pacific coast of Panama.

Diagnosis.—"Shell medium-sized, moderately slender to very slender, whorls not or only slightly constricted at suture, body whorl very long. Nucleus stout, consisting of almost two smooth whorls. Aperture very long, narrow, elliptical, tapering to an acute angle at the posterior end, constricted at anterior end to form a short, wide, slightly recurved, moderately emarginate canal. Siphonal fasciole low. Edge of inner lip forming a definite edge along pillar and parietal wall. Outer lip varicose, its inner edge bearing broad denticles that may be extended into short lirations." (Woodring, 1928, p. 285)

Remarks.—Metula s.s. is known from the Oligocene to Recent. Woodring (1928), believed the Lower Eocene *Metula sylvaerupis* Harris, 1899 deserved subgeneric rank under *Daphnobela* Palmer (1937), and Palmer and Brann (1966) do not follow Woodring's suggestion, and keep the Eocene species from North America under *Metula* s.s.

Metula elongatoides, new species
Plate 15, figures 3–4

Description.—Shell small, very elongate, whorls eight and one-half, protoconch of three and a half whorls, the first two and a half smooth and conical, the final one almost cylindrical, smooth except for a final quarter turn of fine arcuate riblets that gradually increase in strength. Sutures impressed; whorls ornamented with numerous spiral lines, flatter on the lower half of the whorl, nodular on the upper half where crossed by growth lines. On later whorls a few spiral lines on the upper half of the whorl increase moderately in strength, the one margining the suture developing a duplex character. Very occasional weak varices sometimes present. Aperture and canal together a little less than one-third the total length of the shell; outer lip smooth, finely lirate within, not continuing into the interior; columella straight, smooth, anterior canal short, bent to the left and weakly emarginate.

Remarks.—The protoconch places this species in *Metula*; it is the most elongate of all the *Metula* species known to me. In outline it is certainly closer to *Parvisipho* Cossmann, 1889, of which a few species are known from the Eocene of the Paris Basin.

Etymology.—Noting the extremely elongate form of this species.

Type information.—Holotype: PRI 30292; paratype: PRI 30293. Type locality: locality 4.

Material examined.—Eight specimens, the largest (the holotype) 12.9 mm long.

Superfamily **CYMATIOIDEA** Thiele, 1925, p. 90

Family **COLUMBRARIIDAE** Dall, 1909a, p. 213

Subfamily **COLUMBRARIINAE** Dall, 1909a, p. 213

Genus **PSEUDOMETULA**, new genus

Type species.—*Metula gracilis* Johnson, 1899, no. 7005 ANSP, herein. Middle Eocene, Cook Mountain Formation of Texas.

Diagnosis.—Elongate, finely cancellate *Metula*-like shells with varices usually a constant angular distance apart. Protoconch smooth, conical. The suture and varix encroaching onto the previous whorl. Callus plate absent in juvenile specimens, weakly developed in the adult. Outer lip weakly dentate or lirate. Anterior notch shallow.

Remarks.—The genus *Metula* H. and A. Adams, 1853 as known in the Americas includes two disparate groups of species. On the one hand there are the shells exemplified by the Recent *Metula amosi* Vanetta, 1913, *Metula metula* (Hinds, 1845), and similar fossil species such as *Metula gabbi* Brown and Pilsbry, 1911, from the Miocene Gatun Formation of Panama, and *Metula fastidiosa* Casey, 1903, from the Oligocene Red Bluff Formation. These species are long and ovate in shape, evenly cancellate, with a varicose outer lip and denticles on the inner edge; varices except for a possible terminal one are absent. The genus *Metula* has generally been placed in the Buccinidae although Woodring (1928, p. 287) notes it may belong in the Columbellidae. Woodring (1928, pp. 286–287) also believed that the American Eocene *Metula* species should receive subgeneric rank as the whorls of those species have a different shape, a less recurved and less deeply emarginate canal; he suggested that *Daphnobela* Cossmann, 1896b was available. In the Eocene through Oligocene there is a related group of species represented by *Metula sylvaerupis* Harris, 1899, *Metula brazosensis* Johnson, 1899, and *Metula gracilis* Johnson, 1899; these latter species are shorter, have regularly spaced varices that encroach on the preceding whorl, a columellar plate in the adult and a short canal. Woodring's suggestion to assign these latter species to *Daphnobela* is ill-advised; the type is the English Bartonian species *Metula junceum* (Solander, 1766, *non*: J. Sowerby, 1822); this species has a blunt paucispiral protoconch, a fine, evenly ribbed sculpture with occasional growth resting stages, and no varices and no denticles or lirae inside the outer lip. Cossmann (1896a, p. 93) places *Daphnobela* in the Pleurotomidae, whereas most modern authors place it in the Buccinidae as a subspecies to *Metula.* Keen's (1971, pp. 503–504, 509) diagnosis of *Columbraria* agrees well with the characters seen in the three Eocene species, *M. sylvaerupis,* M. *brazosensis* and M. *gracilis* and is remarkably similar to that of *Columbraria (Columbraria) lucasensis* Strong and Hertlein, 1937, and *Columbraria (Columbraria) siphonata* (Reeve, 1844) considering the long intervening time period. The columellar plate, such a prominent feature of modern members of this group, is usually absent in all but the larger Eocene shells but even in modern specimens is only fully developed in mature shells. The lack of a strong columella plate and the more fragile shell than *Columbraria* s.s is deemed sufficient to define this similar genus.

Pseudometula gradus, new species

Plate 15, figures 5–6

Description.—Shell small, fusiform. Protoconch of two and a half whorls, the tip inflated and partially enrolled, a single whorl of smooth, fine riblets appears on the next whorl after which the full cancellate ornament develops rapidly. Later whorls moderately stepped and ornamented with seven spiral lines, the two below the suture larger and wider apart than the remaining. The lines cross over numerous ribs, the intersections nodular. Body whorl with 26 or 27 spiral lines, nodular above the midsection and finer and more closely spaced below. Varices indistinct on early whorls, moderate in size on later ones and number about one per whorl. Outer lip with terminal varix, labrum with numerous equally spaced lirae the entire length of the inner lip and siphonal canal, the lirae continuous. Aperture elongate, canal short, slightly expanded basally and barely notched.

Remarks.—The closest American species is *Metula sylvaerupis* Harris, 1899, from the Hatchetigbee Formation at Woods Bluff, Tombigbee River, Alabama. That species has a different protoconch, a straighter canal, short denticles on the outer lip, and a heavier labial deposit.

Etymology.—The specific name *gradus* (Latin, step), refers to the stepped whorls.

Type information.—Holotype: PRI 30388; paratype: PRI 30389, a juvenile. Type locality: locality 4.

Material examined.—30 specimens, three adult, the largest 29.9 mm length.

Family **CYMATIIDAE** Pilsbry, 1922, p. 356

Genus **DISTORSIO** Roeding, 1798, p. 133

Type species.—Murex anus Linnaeus, 1758, by subsequent designation (Gray, 1847a, p. 133). Recent, Indo-Pacific.

Diagnosis.—Shells with distorted, gnarled apertures; periostracum hairy. Varix on outer lip, aperture more or less constricted, with prominent denticles and with a moderately long canal, columella shield broad.

Remarks.—Recent members of this genus inhabit the warmer waters of the Pacific, Indian and Western Atlantic oceans. The genus is known from the Eocene onward.

Subgenus **PERSONELLA** Conrad, 1865a, p. 21

Type species.—Distorsio septemdentata Gabb, 1860, by monotypy. Claibornian Eocene of the United States.

Diagnosis.—Shell size as *Distorsio* s.s. but with a wider aperture and smaller teeth; columella shield moderately broad.

Remarks.—The subgenus is restricted to the Eocene of North America and Australia.

Distorsio (Personella) nucleoides, new species
Plate 15, figures 11–13

Description.—Protoconch proportionately very large, of four and a half to four and three-quarters inflated whorls, about twice the size of the type of the subgenus. Nucleus minute and pointed, first one and a half whorls smooth, then developing widely spaced longitudinal striae which become close-set by the end of the nuclear whorls, and eight to nine fine spiral striae which start after the second whorl. Adult sculpture begins abruptly and consists of four revolving lines and numerous large ribs which form a reticulated ornament. The interstices have a finer secondary reticulation generated by numerous fine spiral and longitudinal threads. Each whorl generally has one large varix. Ribs obsolete on the lower half of the body whorl, canal moderately reflected and strongly twisted. Outer lip thickened within and bearing five to six denticles, the lower three moderate in size, above that a very small one and above that the two largest. Labial callus with two long denticles on the lower margin of the columella and three smaller ones above. The longitudinal ribs are visible under the upper part of the parietal callus.

Remarks.—This extends the known range of the genus to the lower part of the Claibornian. The Academy of Natural Sciences in Philadelphia has several specimens from the Reklaw Formation at Black Shoals on the Colorado River, Texas, which may be part of the lot sent to Heilprin in 1881; all of these specimens have a worn protoconch but are referable to this species. The emergence of this genus in America may actually have been slightly earlier since Stephenson (1953, p. 35) notes a mold referable to a possible *Distorsio* in sandstone stratigraphically below the Reklaw in northeastern Texas. The Reklaw species can easily be distinguished from *Distorsio (P.) septemdentata* Gabb, 1860, by the larger ornate protoconch. Without the protoconch one notes that *D. (P.) nucleoides* is slenderer with a spire angle of about 43° and four revolving nodular lines on the spire while *D. (P.) septemdentata* is much larger, has a spire angle of about 48°, three coarse nodular lines on the spire and becomes very much more distorted with age.

Etymology.—The specific name *nucleoides* refers to the inflated protoconch.

Type information.—Holotype: PRI 30390; paratype: PRI 33109. Type locality: locality 21.

Material examined.—83 specimens, the largest 8.6 mm length, 4.5 mm width.

Family **NASSARIIDAE** Iredale, 1916, p. 82

Genus **COLWELLIA** Nuttall and Cooper, 1973, p. 208

Type species.—Colwellia fexuosa Edwards *in* Lowry, Etheridge and Edwards, 1866, by original designation. Upper Eocene, Middle Headon beds, Isle of Wight, England.

Original diagnosis.—"Agrees with *Pseudocominella* except in the following respects: seldom exceeds 20 mm in height; protoconch of about two and a half smooth whorls, small, about 1 mm height, initially slightly flattened, first whorl very small; teleoconch with spiral and collabral sculpture of varying strengths; subsutural platform either poorly developed or absent; growth lines of fasciole broadly sinuous as in *Desorinassa*; outer lip often denticulate within." (Nuttall and Cooper, 1973, p. 208)

Remarks.—The genus is restricted to the Middle to Upper Eocene of Europe and North America.

Colwellia bilineata, new species
Plate 15, figures 7–8

Description.—Protoconch of two and a half to two and three-quarters smooth whorls, rounded and rapidly expanding, the first minute, flattened and partially immersed in the next. Adult sculpture begins with close-set very slightly curved longitudinal ribs upon which two or three fine spiral lines develop just below the suture. The spiral lines gradually increase in size throughout the succeeding whorls forming a small concave ramp between them; longitudinal ribs rapidly decrease in size, except on the shoulder area where they form nodes at the intersections with the spiral lines. Each pair of nodes is connected by a short prosocline rib. Spiral lines weak on early whorls, becoming gradually stronger on later whorls, and well defined on the body whorl. A single plication on the lower margin of the columella. Siphonal fasciole bordered by a sharp line, callus deposit thin. A thickened area behind the outer lip.

Remarks.—In some specimens the longitudinal folds are entirely lacking and the revolving lines are free of nodes; specimens exist with all gradations between the smooth form and forms where the post-nuclear longitudinal ribs increase in size over the spire and then become obsolete again over the body whorl. A few specimens develop another finer line below the suture which may also become nodose. On two specimens all three spiral lines are equal in strength, close-set, and have a greater number of ribs and nodes. This seems to correlate with the presence of a small subsutural carina and may warrant subspecific rank although some intermediate forms do occur. Three American west coast species have been assigned to *Colwellia* by Nuttall and Cooper, 1973; this species and the next are the first to be recognized from the Gulf coast area. The character of the siphonal fasciole to which Nuttall and Cooper attached major importance in their diagnosis of *Colwellia* and similar genera, is duplicated almost exactly in this species. Anomalous is the far smaller size of this species, and the lack of denticulation within the outer lip, although few specimens do show some incipient development of that feature. A similar species is *Dorsanum* n. sp. from the Lower Eocene Sabinetown Formation of Texas, but *C. bilineata* may be separated by the subsutural lines of equal strength, the less prominent shoulder and the smooth medial area of the body whorl. A closely similar genus is *Desorinassa* Nuttall and Cooper, 1973, but that genus is distinguished from *Colwellia* by the absence of collabral sculpture, a convex ramp, and the lack of denticles and ribbing within the outer lip. Allmon (1990) has revised the *Bullia* group and recognizes *Colwellia* in the Middle Eocene of Britain and France, and possibly the Miocene of the West Coast of the U.S. I have collected juvenile specimens of *C. bilineata,* or a very similar species from the Seguin Formation, so the genus extends back at least to the base of the Lower Eocene. *Desorinassa* is recognised from the Paleocene to Lower Eocene.

Etymology.—The specific name *bilineata* (Latin, double line), refers to the lines on the shoulder.

Type information.—Holotype: PRI 30391; paratypes: PRI 30393, 30409. Type locality: locality 20.

Material examined.—104 specimens, the largest: 7.0 mm length, 4.0 mm width.

Colwellia sp.

Plate 15, figures 9–10

Remarks.—One specimen was obtained of a *Colwellia* with the outer lip broken but sufficiently distinct to be separated from *C. bilineata.* The nucleus is larger and more flattened than in the above species, the whorls have fine lines that increase in size towards the suture and are not abapically nodular. The whorl profile is rounded with no shoulder and a smaller portion of the body whorl is smoother than in *C. bilineata.*

Figured specimen: PRI 30438, from locality 20.

Material examined.—One specimen, 5.3 mm length, 3.0 mm width.

Genus **TRITIARIA** Conrad, 1865a, p. 21

Type species.—Buccinum mississippiensis Conrad, 1848, by monotypy. Oligocene of Mississippi.

Diagnosis.—Distinguished from species of the very similar genus *Phos* Montfort, 1810, by the more anterior position of the siphonal fasciole, the oval aperture and the protoconch with some collabral costellae.

Remarks.—A few species belonging to the closely similar genus *Antillophos* Woodring, 1928, live in the waters of Florida and the West Indies and are commonly found in sand in waters of shallow to moderate depths. The genus is known from the Eocene and Oligocene of America.

Tritiaria nodosa, new species

Plate 15, figures 16–17

Description.—Shell small in size, whorls eight, nucleus globular and slightly depressed, protoconch of two and a half to three rapidly enlarging whorls, the last one eighth to one quarter of which develop slightly inclined longitudinal folds. The adult sculpture begins with three or four spiral threads of which the lower three develop into thick lines which cross widely spaced collabral folds. Later whorls develop longitudinal lines midway between the original three. These increase in size until on the body whorl a reticulated sculpture is formed. Where the transverse lines cross the longitudinal ones prominent nodes are formed. Labial area margined below by a weak fold, usually with one denticle posteriorly, and more rarely two to four weak folds anteriorly. Siphonal fasciole bounded posteriorly by a large beaded cord which is composed of five to six slightly smaller folds. Profile deeply notched, umbilical slit present.

Remarks.—On most adult specimens the longitudinal folds decrease in size becoming ribs; on some they are so small that a cancellate ornament is generated. In a few specimens the folds do not decrease in size and a more robust type of shell is developed. The change from folds to ribs usually occurs at about the seventh whorl; in a few specimens the ribs even change back to folds. Occasionally the labial ornament is intensified to such an extent as to form wrinkles over the entire surface, somewhat reminiscent of *Cassis*. The species is abundant in bed C of localities 12 to 23, but almost nonexistent in other beds. Three related species are *Tritiaria zacatensis* Gardner, 1945 from the Laredo Formation of Mexico, *Tritiaria hilli* (Harris, 1894) and more distantly *Tritiaria albirupina* (Harris, 1894), both from the Upper Eocene Jackson Group, of which the Mexican species *T. zacatensis* is the most similar. This species has an identical protoconch, similar but larger folds that do not die out on the later whorls, and, as is also the case with the other two species, no finer intermediate spiral and longitudinal lines.

Etymology.—The specific name *nodosa* (Latin, knotty), refers to the nodose character of the sculpture.

Type information.—Holotype: PRI 30394; paratypes: PRI 30395–30397. Type locality: locality 20.

Material examined.—126 specimens, the largest: 7.2 mm length, 3.1 mm width.

Genus **ANTILLOPHOS** Woodring, 1928, p. 259

Type species.—Cancellaria candei d'Orbigny, 1841a. Recent in the West Indies.

Original diagnosis.—"Shell medium-sized, moderately stout. Nucleus consisting of between three to four rapidly enlarging whorls, the last whorl bearing a spiral thread near anterior edge, above which, on the last quarter whorl, lie about five widely spaced, strongly curved, protractive axial riblets. Aperture moderately wide, forming a short, wide, deeply emarginate canal. Siphonal fasciole broad, low, limited by a narrow thread, bearing spiral threads and a weak axial groove, followed by a slight swelling. Edge of inner lip above basal fold bearing several irregular denticles. Parietal wall bearing a ridge near its posterior edge. Near base of outer lip lies a shallow stromboid notch. Interior of outer lip strongly lirate. Sculpture consisting of axial ribs and spiral threads." (Woodring, 1928, p. 259)

Remarks.—to date *Antillophos* has not been recognized earlier than the Miocene. MacNeil *in* MacNeil and Dockery (1984, p. 133) conjectured that *Terebrifusus amoenus* Conrad, 1833b might be a progenitor, but this seems unlikely given these specimens. Most authors treat *Antillophos* as a subgenus of *Tritiaria*; typical *Tritiaria* as recognised above under *T. nodosa*, however, is rather more widely separated from *Antillophos* than are the Miocene representatives of those two taxa. I therefore prefer to treat *Antillophos* as a full genus. The ancestors of this taxon should probably be looked for in *Sassia* or *Ranella*.

Antillophos multilineatum, new species
Plate 18, figures 10–13

Description.—Shell small to medium in size, whorls nine, protoconch of four smooth whorls, the tip swollen and partially enrolled, the last one-third with a weak spiral ridge and weak protractive riblets, transition to teleoconch sculpture gradual. Early teleoconch whorls angular with strong longitudinal folds, ten on the second teleoconch whorl; with age the whorls become more rounded, the folds increase to about 14 and then disappear on the last spire whorl; the final three whorls with one or two varices per whorl, the body whorl with one at the aperture. Spire whorls with six or seven raised spiral lines, the body whorl about 18, between each pair a weaker one and between those, one or two even weaker ones; where crossed by growth lines the spiral sculpture tends to nodularity. Aperture elongate, weak anal sinus present, outer lip broadly and weakly nodular within; inner lip with a posterior duplex parietal fold, anteriorly with a few weak denticles at the start of the short, weakly bent-back canal; siphonal fasciole strong; canal moderately notched.

Remarks.—Despite some similarity to *Sassia (Sassia) conradiana* (Aldrich, 1885), this species cannot be placed in that genus. Genus *Sassia*, as discussed by Wrigley (1932), and used in MacNeil and Dockery (1984), has a regular arrangement of varices spaced at equal angular intervals, a feature not seen in the Reklaw species; the lack of a bent-back canal, a wrinkled or lirate columella also confirm the separation. The subdued spiral ornamentation of the two Paris Basin species *Charonia (Sassia) formosum* (Deshayes, 1865) and *Charonia (Sassia) columbrina* (Lamarck, 1804) indicates some similarity, although both those species also have a bent canal. Palmer and Brann (1966, pp. 873–874) list four species of *Ranella* from the Paleocene and Eocene of the eastern and southern United States. None of these shows much similarity and in fact both the Paleocene *Ranella showalteri* (Conrad, 1860) and Lower Eocene *Ranella tuomeyi* Aldrich, 1886, appear to belong in *Sassia* if Wrigley's (1932) diagnosis is followed. With reference to published figures and diagnoses the closest species would appear to be *Eutritonium (Epidromus) autopsis* (Conrad, 1860). This species has not been rediscovered *fide* Harris

(1899, p. 66) and since neither locality or age is known, Palmer and Brann (1966, p. 675) recommended the species should be disregarded. If the generic characters described by Woodring are interpreted in a loose sense this species fits well in *Antillophos*. Well-preserved juvenile specimens show a faint carina or line in the lower quarter of the last protoconch whorl and the gradual development of numerous protractive riblets. The basal columellar fold, the labial lirae and posterior parietal-wall ridge are all present but very weakly defined. The stromboid notch is only seen on the two largest specimens and is very shallow. Very confusingly, juvenile and young adult specimens of this species have a form and ornament remarkably similar to Weches and Stone City specimens of *Streptochetus limulus* (Conrad, 1833b), only the conical, smooth protoconch and lack of columella notch can reliably distinguish the two taxa in the juvenile state. More mature specimens of *S. limulus* are easily distinguished by the squat form, the swollen subsutural collar and concave ramp, the terminal fold of the columella, and the twisted canal.

Etymology.—*Multi* (Latin, many) *lineatum* (Latin, lines), referring to the many fine spiral lines ornamenting the whorls.

Type information.—Holotype: PRI 30557; paratypes: PRI 30558, 30559. Type locality: locality 4.

Material examined.—15 specimens, the largest 20 mm length, 8.0 mm width.

Genus **BUCCINANOPS** d'Orbigny, 1841a, p. 434

Type species.—*Buccinum cochlidum* Dillwyn, 1817 (non Kiener, 1834), by subsequent designation (Gray, 1847a, p. 139). Recent, Brazil to Patagonia.

Diagnosis.—Shell bucciniform, usually thick and robust in appearance. Spire never greater than one-third shell height. Columella bears pronounced terminal fold. Internal sculpture almost always lacking. External sculpture usually simple. Parietal callus usually expanded onto body whorl but never thick. Anterior canal relatively wide and elongate. Sutures often enamelled. (After Allmon, 1990)

Remarks.—The genus is known from the Eocene onward.

"Buccinanops" ellipticum reklawensis, new subspecies
Plate 15, figures 14–15

Description.—Shell smooth, fusiform in shape, whorls shouldered, those of the spire slightly convex, body whorl strongly convex. Callus thick with an anterior swelling on the columella and typically extending over most of the spire. Longitudinal plications in spire weak to absent. A faint band below the suture shows sigmoidal lines of growth. Basal groove wide, margined above by a narrow band and occurring just below the center of the body whorl. The wide groove runs up to the siphonal fasciole and has an obsolete medial depression there corresponding to a thickening of the shell within the outer lip. An obsolete depression is present on the lower margin of the callus.

Remarks.—The Reklaw subspecies can be distinguished from *Buccinanops ellipticum* (Whitfield, 1865), a Lower Eocene species, by its more globose outline, the more prominently shouldered whorls and the basal groove occurring just below the center of the body whorl, rather than in the lower third as in *B. ellipticum* s.s. A similar, although slenderer species of *Buccinanops* occurs in abundance on the Little Brazos River at a locality which has been interpreted as being deposited in a high marsh environment with marine grasses. The fact that the genus is relatively uncommon in other localities where a marine or lagoonal environment is inferred suggests that the Reklaw species may have favored a similar habitat. Allmon, (1990, pp. 56–59) considered the placement of *B. ellipticum* to be problematical and probably not even in the family Nassariidae, no doubt partially due to the lack of the terminal columellar fold.

Etymology.—Referring to the Reklaw Formation where the species occurs.

Type information.—Holotype: PRI 30410. Type locality: locality 20.

Material examined.—16 specimens, the largest: 26.0 mm length, 14.5 mm width.

Genus **BULLIA** Gray, 1834, p. 596, pl. 37, fig. 8

Type species.—*Bullia semiplicata* Gray, 1834, by monotypy. Recent, off the coast of West Africa.

Original diagnosis.—"Animal without eyes; tentacles long and slender. Foot greatly expanded, and bifid behind. Shell ovate or turrited; spire more or less acuminated, sutures enamelled; inner lip excavated in the middle, callus posteriorly; aperture oval, moderate. (Gray, 1853, p. 112)

Remarks.—The genus is known from The Eocene onwards.

Bullia altilis harrisi Palmer in Price, 1928
Plate 15, figures 1–2

Bullia altile harrisi Palmer *in* Price, 1928, p. 29, pl. 7, fig. 7, 11, 12, 15.
Bullia altilis harrisi Palmer, 1937, p. 290, pl. 39, figs. 2, 3; Palmer and Brann, 1966, p. 543.
"Bullia" altilis (Conrad, 1832b). Allmon, 1990, p. 57.

Original description.—"Shell small, irregular in shape, flattened ventrally, protruded to the left, the anterior notch as in *B. altilis*; spire is usually depressed and enveloped in the callus; the callus spreads posteriorly and laterally and covers the greater portion of the shell; usually three distinct, large nodes or bumps occur, one on the inner lip just above the middle, one on the dorsal side of the body whorl and one laterally in the middle, left portion of the body whorl. Many specimens have the tri-nodular character developed strongly and the spire so enveloped in the callus that the true generic identity of the form is obscured. There are specimens which show the anterior notch and groove of *Bullia*." (Palmer in Price, 1928, p. 29)

Remarks.—Two worn specimens were obtained which appear to be the above species. The species is known from the Queen City formation which adjoins the Reklaw formation on the Colorado River, near Smithville, Bastrop County, Texas. Allmon (1990, p. 58) considers that the *Bullia altilis* complex belongs to an undescribed genus, possibly in the Olividae, Ancillinae. The analysis necessary to confirm this however is not performed here, and the genus is left where it has been placed previously.

Type information.—Holotype: PRI 360; paratypes: PRI 356, 357. Type locality: Gazely Creek, Colorado River, near Smithville, Texas. Range: Reklaw and Queen City formations of Texas. Figured specimen: PRI 33127 from location 20.

Material examined.—Two specimens, the largest 18.0 mm length, 14.0 mm width.

Family **FASCIOLARIIDAE** Gray, 1850b, p. 67

Subfamily **FUSININAE** Swainson, 1840, p. 76

Genus **FALSIFUSUS** Grabau, 1904, pp. 80–81

Type species.—Fusus meyeri Aldrich, 1886, by original designation. Lower Eocene, Sabine Group of Alabama.

Original diagnosis.—"Shell fusiform with long and slender spire and a canal of about the same length. Protoconch merging into the whorls on the conch, no sharp demarkation being apparent. The first two whorls of the protoconch are generally smooth, the apical one minute, gradually increasing in size. The three to four whorls which constitute the apical series form a rather narrow cone. Third whorl with five closely crowded, more or less oblique riblets, which are in part gently concave forward. These after the completion of the third, or sometimes an additional whorl, quickly merge into the normal whorls of the conch. A basal carina usually marks the ribbed whorls of the apical series, this carina appearing just above the suture. Whorls of the conch as in *Fusus*." (Grabau, 1904, pp. 80–81)

Remarks.—Falsifusus was created for shells of fusoid form and a paucispiral protoconch of *Pleurotoma* type. The genus is known from the Upper Cretaceous to Recent.

Falsifusus ottonis (Aldrich, 1886)
Plate 16, figures 9–10

Fusus meyeri Aldrich, 1886, p. 21 in part, pl. 3, fig. 12.
Fusus ottonis Aldrich, 1897, p. 6 new name for *F. meyeri.*
Falsifusus meyeri (Aldrich). Grabau, 1904, p. 81, pl. 17, fig. 9.
Falsifusus ottonis (Aldrich). Wenz, 1943, p. 1260, fig. 1390.

Original description.—"Shell elongate fusiform, spire slender, acute; whorls fourteen; surface at the spire and body whorl with seven longitudinal folds, which are spirally arranged, crossed by raised rounded striae, generally seven in number, rather distant, the central one making a sharp carina on the center of each whorl, with erect longitudinal tubercles at the intersections; spaces between striae showing only lines of growth; canal very long, spirally striate with alternate raised lines; lines of growth very numerous and almost obsolete; mouth small, oblique-ovate; outer lip incurved, smooth. Locality: lower bed, Woods Bluff Alabama, Matthews Landing, Alabama." (Aldrich, 1887, p. 21)

Remarks.—On average the Reklaw specimens have fewer whorls and seven to nine spiral lines (most commonly eight) as against seven on those from the Sabinian Stage. The development of the longitudinal folds is a variable character and ranges from being obsolete to being so prominent as to cause the sutural line to be wavy. In one juvenile specimen the canal is one and a third the length of the spire and body whorl combined. This species, with minor variations, has been recognized from the Midway Group of Alabama to the Sabinian Stage, the present occurrence extending the range to the start of the Claibornian Stage.

Type information.—Holotype: USNM 638756. Type locality: Woods Bluff, Tombigbee river, Clarke County, Alabama. Range: Midway, Sabine to Claiborne. Figured Reklaw specimen: PRI 30447, from locality 21.

Material examined.—151 specimens, the largest 50 mm.

Genus **FUSINUS** Rafinesque, 1815, p. 145

Type species.—Murex colus Linnaeus, 1758, by monotypy. Recent, Indo-Pacific.

Diagnosis.—Shell large, spindle-shaped. Protoconch of one and a half whorls, usually smooth or with the last half whorl with axial riblets, terminated by a varix. Whorls convex, with spiral lines and usually with collabral ribs that disappear on the lower part of the body whorl. Body whorl with moderate to long neck and unnotched beak. Aperture ovate, gutter present, canal open, straight and generally twisted. Outer lip serrate at edge, lirate within, edge of inner lip continuous along parietal wall. Columella weakly concave, folds absent, terminated in the adult by a parietal ridge.

Remarks.—The genus is well represented from the Miocene upwards in the Gulf and Atlantic coastal plains, and is widely distributed in warm waters today.

Fusinus claibornica, new species
Plate 16, figures 15–16

Description.—Shell large, whorls eight to nine, nucleus minute, protoconch of two and a half whorls, the last half whorl starting with faint spiral lines, then gradually developing faint collabral lines. Spire with nine to 11 rounded ribs per whorl that are overriden by many flat-topped spiral lines and smaller intermediate ones. Three large spiral lines dominate the sculpture of the early whorls and are situated below an indistinct shoulder, occupying a little less than half the whorl. Most lines tend to become subequal in size on the later whorls but some intermediate threads still occur. On the body whorl the entire spiral and collabral sculpture is much more subdued while on the beak it is more prominent again with the spirals alternating in size. Aperture ovate, widely and weakly channeled above, outer lip serrate and with widely spaced lirae within. Columella weakly excavate, terminated below by a ridge, canal twisted. Parietal wall forming a large umbilicus in the adult, very small in the juvenile, the left hand side margined by a prominent siphonal fasciole.

Remarks.—It is possible that two very closely related species are at hand as two individuals have a slightly greater apical angle and about one more costa per whorl. Whether this represents two species or the variation within one must wait for the discovery of further specimens. The species closest to *F. claibornica* is *Fusinus nexilis* Dall, 1890, from the Miocene Tampa Silex beds at Ballast Point, Tampa Bay, Florida. This occurrence of *Fusinus* s.s in the Eocene of North America is interesting, as it places the earliest American representative at a similar time to the earliest European ones, found in the Eocene of the London, Hampshire, and Paris Basins. Most European representatives are closer to the type species of the genus, *Fusinus colus* (Linnaeus, 1758), with its very slender shape and extremely long canal than are the American species. One European species that appears more related to the American ones is *Fusus valenciennesii* (Grateloup, 1840), from the Miocene of Bordeaux, France.

Etymology.—Noting the first Claibornian representative of *Fusinus*.

Type information.—Holotype: PRI 30399; paratype: PRI 30400, a juvenile. Type locality: locality 20. Paratype from locality 4.

Material examined.—14 specimens, the largest complete 50 mm length, 22 mm width. One large incomplete specimen is estimated to have been about 145 mm in length.

Subfamily **PERISTERNIINAE** Tryon, 1881, p. 47

Genus **LATIRUS** Montfort, 1810, p. 531

Type species.—*Latirus aurantiacus* Montfort, 1810, (=*Murex gibbulus* Gmelin, 1791) by original designation. Recent, Australia and Fiji.

Diagnosis.—Shell solid fusiform. Whorls with broad solid collabral costae and overriding spiral lines or ribs. Body whorl greater than half the total length, neck short. Aperture ovate, columella straight with faint folds, canal moderate in length, siphonal fasciole prominent margining an umbilical slit. Outer lip lirate within, basal notch absent.

Remarks.—The prominent siphonal fasciole margining a small umbilicus is not usually present on Claibornian representatives of *Latirus* s.s. except on mature and gerontic individuals. Only on *Latirus moorei* Gabb, 1860 has it been noted as a well developed feature. The genus is very common in the Paleogene of the Gulf and Atlantic coastal plains, 37 species having been reported. The genus is known from the Upper Cretaceous to Recent.

Subgenus **POLYGONA** Schumacher, 1817, p. 241

Type species.—*Polygona fusiformis* Schumacher, 1817, by original designation. Recent, Florida and the West Indies.

Diagnosis.—Protoconch conical, nucleus squat. Shell slender, whorls carinate and ramped. Aperture long and narrow, posterior channel formed by the parietal ridge, constricted below to a slightly emarginate canal. Siphonal fasciole high and narrow, columella with three folds.

Remarks.—Most of the Claibornian and Jacksonian species of *Latirus* are probably referable to this subgenus. The subgenus is known from the Upper Cretaceous to Recent.

Latirus (Polygona) traceyi, new species
Plate 16, figures 3–4

Description.—Shell small, solid. Whorls nine, protoconch smooth and conical, of about four whorls, the final half turn with fine arcuate riblets, nucleus swollen. Whorls convex, ornamented with seven nodular costae per whorl and three prominent spiral lines causing the whorls to be tricarinate. The uppermost spiral is very weak on early whorls but slowly increases in strength to become equal to the other two. The interstices between the main spirals with fine lines of many sizes ranging down to the microscopic, the interstice between the suture and uppermost spiral with two to four larger lines. Body whorl with 11 larger spiral lines and many small ones that decrease in strength towards the base. Aperture ovate, outer lip strongly lirate within, edge fluted by the large spiral lines, gutter formed by a thick deposit of callus. Columella straight with three weak folds, canal moderate in size, bent and twisted, siphonal fasciole weak, umbilicus a chink or absent.

Remarks.—Two species are quite closely related: *Latirus sexcostatus* Johnson, 1899, from the Landrum Member of the Cook Mountain Formation and *Latirus (Polygona) vokesae* Allen, 1970, from the Saline Bayou Member of the Cook Mountain Formation in Louisiana. *Latirus (P.) traceyi* is distinguished from *L. (P.) vokesae* by the protoconch possessing only half a turn of riblets rather than two turns, a stronger spiral sculpture and slenderer profile. *Latirus sexcostatus* has six costae per whorl, only two prominent spiral lines, a smooth and shining surface and generally more subdued spiral sculpture.

Etymology.—The species is named in honor of Steve Tracey, a worker on the English Tertiary Mollusca, for the many productive discussions and for the loan of much English material.

Type information.—Holotype: PRI 30401; paratype: PRI 30402. Type locality: locality 4.

Material examined.—Eight specimens, the largest 13.0 mm length.

Genus **TEREBRIFUSUS** Conrad, 1865a, p. 28

Type species.—*Buccinum amoenum* Conrad, 1833b, by monotypy. Claibornian Eocene of the United States.

Diagnosis.—Shell small to medium, fusiform, spire high, somewhat coeleoconoid. Protoconch whorls smooth, rounded. Whorls convex, with prominent longitudinal costae and spiral lines, sutures impressed. Body whorl large, aperture long, posterior gutter, canal short and deeply notched, siphonal fasciole present. Columella straight, with numerous folds, inner lip smooth.

Remarks.—The genus is restricted to the Eocene of North America.

Terebrifusus multiplicatus (H. C. Lea, 1841)

Plate 16, figures 11–12

Terebra multiplicata H. C. Lea, 1841, p. 101, pl. 1, fig. 19; 1849, p. 106; Harris, 1895c, p. 29; Pace 1902, p. 110.

Mitra (Terebrifusus) multiplicatus (H. C. Lea). de Gregorio, 1890, p. 77, pl. 5, fig. 65 copy H. C. Lea.

Terebrifusus multiplicatus (H. C. Lea). Palmer, 1937, p. 308, pl. 53, figs. 3, 8, 11, 14; pl. 88, fig. 4 type; Brann and Kent, 1960, p. 854; Palmer and Brann, 1966, p. 950; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, p. 18, 33

Remarks.—The Reklaw specimen is slightly slenderer that the later Claibornian specimens and shows the fine intermediate spiral lines between the major ones on the later whorls that is characteristic of *T. multiplicatus.* The major difference distinguishing the Reklaw species is the almost complete absence of the columellar plications, their place being taken by denticle-like swellings at the edge of the columella. Examination of numerous specimens of the species from the Lower Claiborne shows the strength of the plicae to be quite variable; specimens range with columellar plications that are almost absent to those that are very prominent.

Type information.—Lectotype: ANSP 13160. Type locality: Claiborne Bluff, Alabama River, Alabama. Figured Reklaw specimen: PRI 30539, from location 20.

Material examined.—One specimen, 8.2 mm length.

Genus **MAZZALINA** Conrad, 1860, p. 295

Type species.—*Mazzalina pyrula* Conrad, 1860, by monotypy. Eocene, United States.

Diagnosis.—Shell small to large, inflated and usually short. Whorls flat or concave-convex, carinated below the suture, surface smooth or with fine spiral lines, stronger basally. Body whorl very large and inflated with a somewhat twisted canal and small siphonal fasciole. Aperture pear-shaped, notched above and constricted below at the start of a moderately long wide canal that is bent to the left. Outer lip thin, prosocline, inside smooth or plicate. Columella strongly concave above, smooth or with folds, below bent to the left.

Remarks.—The genus is close to *Bulbifusus* Conrad, 1865a, but Harris (1894, p. 165–166) shows that the two genera are probably synonymous on the basis of a large collection from the Eocene of Arkansas. Wenz (1944) reports the genus as ranging from the Upper Cretaceous to the Eocene and probably also the Miocene. Cossmann (1901a, p. 52), placing a rather wider interpretation on the genus, has it ranging to the Recent in the Philippines.

Mazzalina conica, new species

Plate 16, figures 5–6

Description.—Shell medium in size, spire short and cyrtoconoid. Whorls five (nuclear whorls not known), convex, carinate, with a prominent ramp that progressively increases in size and angle, suture channeled. Early whorls tuberculated below the carina, later ones lose the vertical ornament and possess spiral lines that increase in size with growth. Body whorl very large and smooth, base with prominent spiral lines. Aperture ovate, notched above, outer lip lirate within, columella smooth, excavated, canal short, reflected and slightly emarginate.

Remarks.—The cyrtoconoid profile, convex whorls and prominent carina on the spire whorls can immediately distinguish this species from *Mazzalina inurata* (Conrad, 1833a). This species is also no closer to the Sabinian Stage representative *Mazzalina plena* (Aldrich, 1886), a species that Harris (1899) regarded as a slight variation from the Claiborne and Jackson forms.

Etymology.—The name *conica* (Latin, cone), refers to the shape of the spire.

Type information.—Holotype: PRI 30403. Type locality: locality 14.

Material examined.—Two specimens, the largest 17.0 mm length, 11 mm width.

Genus **SURCULITES** Conrad, 1865d, p. 213

Type species.—Surculites annosa Conrad, 1865d, by original designation. Eocene, Shark River Formation, Shark River, New Jersey.

Original diagnosis.—"Turrited, spire elongated; whorls angulated above the middle, with an impressed revolving line above the suture; whole surface marked with fine, revolving, wrinkled lines, becoming large and distinct towards the base." (Conrad, 1865d, p. 213)

Remarks.—Prior to Glibert (1938, p. 99) who placed *Surculites* in the Galeodidae, the genus had always been assigned in the Turridae. Wrigley (1939, pp. 281–283), after an analysis, concluded that the earlier assignment of *Surculites* to the Turridae was incorrect, and that the genus probably should be placed somewhere between the families Fusinidae and Buccinidae. Powell (1966) agreed with Wrigley's analysis. Wenz (1943), Gardner (1945), Korobkov (1954), Palmer and Brann (1966), and Squires (1987), have continued to place the genus under the Turridae. I find Wrigley's argument convincing and follow his and Powell's assignment. The genus *Surculites,* is confined to the Eocene of Europe and North America.

Surculites lapillus, new species

Plate 16, figures 7–8

Description.—Shell large for the genus, fusiform and with a conical spire. Whorls eight and a half to nine, protoconch of two and a half to three smooth whorls, rapidly increasing in size. Adult sculpture with a broad rounded keel, a concave shoulder which is produced into a vertical flange and which borders the strongly channeled suture. Spire whorls concave below the shoulder which causes a slight carination to become apparent by the body whorl. Adult ornament of crowded spiral and longitudinal lines, the spiral lines alternating in size above the shoulder, stronger below it. The weaker spiral lines have a tendency to be duplex in character, the space between the lines covered with collabral lines, the intersections with the spiral lines forming nodes and having a strikingly tessellated appearance. Aperture elongate-triangular, notched posteriorly. Inner lip with a weak anterior callus deposit, canal long and obscurely twisted anti-clockwise, anterior notch shallow. The genus is known from the Eocene through the Miocene.

Remarks.—This is a very distinctive species whose closest analog seems to be *Surculites cabezi* Gardner, 1945 from the Weches Formation of Texas and the Laredo Formation of Mexico. The present species is distinguished by its more elongate form, the rounded shoulder and finely beaded ornamentation.

Etymology.—The specific name *lapillus* (Latin, bead), refers to the beaded surface of the whorls at the intersections of the lines.

Type information.—Holotype: PRI 30406; paratype: PRI 30407, a juvenile. Type locality: locality 20.

Material examined.—Five specimens, two large ones (the holotype 33.0 mm length), 15.0 mm width, one juvenile with a perfectly preserved protoconch and two fragments.

Genus **CLAVILITHES** Swainson, 1840, p. 77

Type species.—Clavilithes longchaeus Lamarck, 1803, by subsequent designation (Grabau, 1904, p. 105). Eocene of England and France.

Original diagnosis.—"Unequally fusiform, the body whorl and spire being conic, and the canal suddenly contracted and attenuated; terminal whorls papillary; inner lip thick; pillar smooth" (Swainson, 1840, p. 304).

Remarks.—Clavilithes is rather uncommon in the Stone City and Cook Mountain Formations of East Texas, its place seemingly taken by the closely similar genus *Papillina* Conrad, 1855. *Papillina* can be distinguished from *Clavilithes* by its spinose periphery and higher multispiral protoconch. The genus is known from the Paleocene to Pliocene.

Clavilithes parvetorbis, new species

Plate 17, figures 1–2

Description.—Shell fusiform, spire coeloconoidal, whorls 12 in adult, first one or possibly two nuclear whorls missing from all available material. First extant whorl smooth and rounded, the next one with riblets that are crossed after a quarter of a whorl by seven spiral lines. The next six whorls have about seven rounded longitudinal folds per whorl, concave above spiral lines. By the eighth whorl the folds have become obsolete and later whorls have smooth and almost vertical sides. Sutures deeply impressed, shoulder prominent and margined below by an impressed spiral line, the remainder of the spire whorls with faint to obsolescent spirals. Body whorl bicarinate, beak long and straight, columella moderately excavated. Aperture long, elliptical and with a prominent channel which is margined below with a strong line; a prominent notch is formed where this line meets the suture. Area below the body whorl carination with five spiral lines to the end of the beak.

Remarks.—This species has close affinities with *Clavilithes texanus* Harris, 1895a. That latter species has a straight-sided spire with more subdued spiral lines, a prominent rounded carina, and a well-defined subsutural excavation. The species bears a remarkable resemblance to several European species, in particular to *Clavilithes scalaris* (Lamarck, 1816). From the illustrations alone, the greatest resemblance might be to *C. scalaris,* but a hand comparison with specimens of *Clavilithes britannicus* Wrigley, 1927 from the Barton beds of England shows that species to be a closer match. On the Reklaw specimens the sutures are more deeply channeled, and have a slightly less acute angle; otherwise the specimens are practically indistinguishable. The author hesitates, however, to describe this as a species or subspecies of a European form without further study and more material, especially of a form such as *Clavilithes* which has relatively few distinguishing morphological characteristics. It is therefore named as a distinct species here.

Etymology.—The specific name *par* (Latin, like) *vetorbis* (latin, old world), refers to the close resemblance to many old world species of *Clavilithes.*

Type information.—Holotype: PRI 30408; paratype: PRI 30409, a juvenile. Type locality: locality 21.

Material examined.—28 specimens, the largest essentially complete: 87.0 mm length, 30.0 mm width. One large broken specimen is estimated to have been 120 mm in length.

Clavilithes? acus, new species
Plate 16, figures 13–14

Description.—Whorls 13, protoconch multispiral, smooth, narrowly conical of five whorls; transition to teleoconch marked by a strong varix. Teleoconch whorls margined by a swollen collar, constricted below, coarsely vertically nodular with seven nodules on early whorls, ten on the body whorl, the nodules becoming obsolete towards the subsutural collar. Surface ornamented by flat spiral bands, stronger and often duplex on later whorls, occasional intermediate weaker lines, all crossed by minutely scabrous growth lines which form a shallow "turrid-like" notch over the rounded carina. Aperture long, columella long and straight with a thick, smooth callus deposit.

Remarks.—This is a puzzling species which in the early teleoconch stage resembles *Clavilithes kennedyanus* Harris, 1895a, from the Weches Formation, but lacks the mammillated protoconch of that and other species of *Clavilithes.* The multispiral conical protoconch also precludes an assignment to *Fusinus* Rafinesque, 1815, or *Falsifusus* Grabau, 1904, to which a certain resemblance is also apparent. Harris's (1895a) drawing of *C. kennedyanus* shows a specimen in which the early ribbed stage gives way fairly rapidly to a smooth stage; in my experience that transition is fairly gradual in Weches specimens and *C. kennedyanus* resembles a smooth variant of *C.? acus*; the "turrid-like" growth lines are also apparent on *C. kennedyanus* although to a lesser degree. Despite the similarity to *Clavilithes,* the protoconch is atypical of Clavilithes s.s. and the lower part of the aperture shows no constriction as is also typical in that genus. The aperture and canal in fact are very *Fusinus*-like and *C.? acus* combines characters of the two genera. I can find nothing similar described in the literature.

Etymology.—The name *acus* (Latin, needle), notes that feature of the protoconch.

Type information.—Holotype: PRI 33107. Type locality: locality 4. Paratype: PRI 30398, from locality 20.

Material examined.—Four specimens, three juvenile. The largest (the holotype) 50.4 mm long.

Genus **LEVIFUSUS** Conrad, 1865a, p. 17

Type species.—*Fusus trabeatus* Conrad, 1833a, by subsequent designation (Cossmann, 1901b, p. 14). Eocene of the United States.

Diagnosis.—Shell medium in size to large; protoconch conical, of one and one half to two smooth, conical whorls; teleoconch whorls carinated, the carina with serrations or spines; ramp concave, below the carina cylindrical or weakly inflated; sculpture of fine spiral lines that are stronger on the basal part of the body whorl; axial sculpture weak or absent, sometimes with low folds; body whorl often with a lower serrated keel; aperture oval, smooth, outer lip lirate within; canal long and somewhat twisted.

Remarks.—*Levifusus* ranges from the Paleocene (doubtfully Upper Cretaceous) to the Eocene. It is a common component of the Gulf Coast Paleogene, over 30 species being recognised. The genus has been used in a very wide sense, to include forms such as *Levifusus prepagoda* Palmer, 1937, with its coeloconoidal spire, strong axial sculpture on the early whorls and a

Busycon-like protoconch, and forms such as the strongly spinose *Levifusus spiniger* Conrad, 1848.

Levifusus? serrae, new species

Plate 18, figures 4–5

Description.—Shell small, broadly fusiform, of up to seven and one-quarter whorls. Protoconch conical, of three to three and one half rounded whorls, the first two to two and one half smooth, last one with arcuate riblets. Spire whorls strongly carinate with a serrated keel, the rounded tips of which are the extension of low folds, the folds becoming obsolete above the suture and continuing down to the suture below. On the body whorl the folds continue to the second carina where nodes are formed at the intersections. Suture impressed, shoulder concave with eight to nine strong spiral cords. Below the keel are similar cords, increasing in strength as they approach the anterior canal. Outer lip thin, aperture pyriform; anterior canal long and bent slightly to the left, constricted at its initiation and emarginate towards the base.

Remarks.—With the exception of the protoconch, this species closely resembles the early whorls of *Levifusus spiniger* Conrad, 1848, from the Oligocene of Mississippi. *L. spiniger* has a protoconch of two smooth whorls, weaker spiral lines, and the whorls are lower. This probably indicates all species of *L.? serrae* found so far are juveniles. I am indebted to David Dockery for pointing out the relationship to *L. spiniger.* Confusingly, this species appears close to several turrids, in particular *Clinura calliope* (Brocchi, 1814) (*cf.* Pinna and Spezia, 1978, pl. 31, figs. 2, 2a), a species from the Neogene of Crete. This species is, however, much larger, and *Clinura* Bellardi, 1875, has a polygyrate, narrowly conical protoconch, the later whorls cancellate, a smooth shoulder area, and a sinus with the apex very near to the suture. The type of protoconch seen in *L.? serrae* is also exhibited in several other turrid genera, for instance the New Zealand genus *Tahusyrinx* Powell, 1942. I have doubtfully assigned the species to *Levifusus,* as the protoconch is unlike any other *Levifusus* species I am aware of.

Etymology.—The specific name *serrae* (Latin, saw), refers to the saw-tooth character of the keel.

Type information.—Holotype: PRI 30467; paratypes: PRI 30468, 30469. Type locality: locality 20.

Material examined.—21 specimens, the largest: 10.5 mm length, 5.4 mm width.

Family **MELONGENIDAE** Gill, 1867, p. 145

Subfamily **MELONGENINAE** Gill, 1867, p. 145

Genus **CORNULINA** Conrad, 1853a, p. 321

Type species.—Cornulina armigera Conrad, 1833a, by subsequent designation (Fisher, 1884, p. 621). Eocene of the Paris Basin and England.

Diagnosis.—Shell short-fusiform to globose, with two rows of spines on the body whorl; columella rounded; siphonal fasciole prominent and ridged; canal strongly bent to the left; labrum with three teeth, two of them very small.

Remarks.—Cornulina is restricted to the Eocene of the Americas, Africa and Europe.

Cornulina minax dockeryi, new subspecies

Plate 17, figures 3–6

Description.—Shell medium sized to large, heavy; spire short, most of the ornamentation covered with a thin coat of callus; body whorl short, the upper and lower carinae with a row of short spines, equal-sized in the adult, in the juvenile the lower carina is a noded cord; spiral ornamentation weak on the body whorl, stronger below on the base; aperture large, rounded, channeled posteriorly; columella rounded, slightly excavated; siphonal fasciole prominent; canal short and bent to the left.

Remarks.—This Reklaw subspecies is differentiated from *Cornulina minax* by its lower form, smaller spines, and more subdued spiral ornamentation. The species *Cornulina armigera* (Conrad, 1833a) exhibits few characters that can be used to differentiate the various races in the Sabinian and Claibornian stages in the American Eocene. Typically the Sabinian forms are more spinose and high-spired than the Claibornian forms, particularly in the adult shell. Both forms were originally grouped together under *C. armigera* but Palmer and Brann (1966) split the Sabinian, Cook Mountain Formation and Gosport Sand species, indicating they should be differentiated. The Sabinian species are certainly differentiable for in addition to the characters mentioned above it can be noted that the basal spiral lines evenly decrease in strength anteriorly and the upper row of spines is continued over the midsection of the body whorl as low folds. None of the specimens from the Cook Mountain or Gosport Sand formations shows that feature. With regard to the splitting of the Cook Mountain and Gosport Sand specimens I can find no character that can consistently separate them; a large number of individuals from the Stone City Formation exhibit a range of variation that includes those typified by the Gosport Sand form and in fact also approaches closely the Jacksonian species, *Cornulina dalli* (Harris, 1894). Dockery (1980) has separated the Sabinian stock under *Cornulina minax compressa.* This latter species occurs in the Bashi, Nanafalia and Pendleton formations of Alabama, Mississippi and Texas. This species is differentiated primarily by the whorls impinging on the previous row of spines, a strong spiral groove below the lower row of spines and further grooves of decreasing strength towards the base. I do not believe that the first character can be used in differentiation as it is seen widely throughout the group. The holotype shows low folds continuing below the spines, and that feature together with the basal grooves of decreasing strength, relate it to *Cornulina minax* (Solander, 1776), rather than *C. armigera.* The compressed form and other characters, however, do warrant its separation as a distinct subspecies of *C. minax.* The adult Reklaw specimens are rather worn but can still be assigned under *C. minax.* The juvenile specimens, one of them perfectly preserved, are very different from the juveniles of the Cook Mountain and Gosport Sand formations and show the folds under the row of spines very well. The juveniles of *C. armigera* and its subspecies all lack the lower row of spines, a character developed in the adult form. The European species *C. minax* is a high-spired species that has a slight subsutural swelling at all stages of growth but does not have the later whorls encroaching on the earlier ones. The differences between the species are more apparent in the juveniles, the profile approaches that of a spinose *Cornulina dalli cetavia* Palmer, 1947, rather than one of the *C. armigera* varieties. Juveniles of *C. minax* from the Bracklesham beds of England are very close to juvenile Reklaw specimens of *C. minax dockeryi* with the exception of the coarser basal lines of *C. minax.*

Etymology.—In honor of David Dockery of the Mississippi Bureau of Geology.

Type information.—Holotype: PRI 30411, from locality 4.

Material examined.—Eight specimens, the largest 40 mm length, 30 mm maximum diameter.

Genus **SYCOSTOMA** Cox, 1931, p. 291

Type species.—*Fusus bulbiformis* Lamarck, 1803, by original designation. Eocene of the Paris Basin and England. Cox (1931) replaced *Sycum* by *Sycostoma. Sycum* Bayle, 1880, is itself a new name for *Leiostoma* Swainson, 1840, the original diagnosis of which is given below.

Original diagnosis.—"Equally fusiform, but ventricose in the middle; shell entirely smooth, almost polished; inner lip thickened and vitreous; base of the pillar very straight. Fossil only." (Swainson, 1840, p. 308)

Remarks.—The genus is known from the Upper Cretaceous to the Oligocene.

Sycostoma texana, new species
Plate 17, figures 13–14

Description.—Shell medium in size, spire coeloconoid, whorls nine, shouldered, the shoulder profile level on the spire, becoming a shallow depression by the body whorl. Suture impressed and with impressions of four or five spiral lines below it. Body whorl large, inflated, and with a few spiral lines on the base which curve into a weak siphonal fasciole. Aperture oval-elongate, outer lip smooth within except for a few widely spaced impressed striae in the upper half. Columellar lip smooth with a coating of callus and with a slight anterior swelling which leads into a short slightly recurved canal.

Remarks.—The only other species referred to this genus in the Eocene of the Gulf and Atlantic coastal plains is *Sycostoma americanae* Palmer, 1937, from the Lisbon Formation of Alabama; that species has a greatly enlarged body whorl and has a prominent shoulder. The common species *Neptunea enterogramma* Gabb, 1869, which Palmer (1937, p. 323–324) also assigned to *Sycostoma,* is now assigned to *Bolis* Gardner, 1939. This latter genus can be distinguished by the straight-sided adult whorls, the channeled suture and more prominent callus.The Reklaw species is closer to the Paris Basin species *Sycostoma pyrus bulbiformis* Lamarck, 1803, and can be distinguished from it by the expanded body whorl and the impressed suture.

Etymology.—Noting the first discovery of the genus in Texas.

Type information.—Holotype: PRI 30414. Type locality: locality 20.

Material examined.—One specimen, 30.0 mm length, 16.0 mm width.

Genus **MICHELA** Gardner, 1945, p. 230

Type species.—*Levifusus trabeatoides* Harris, 1895a, by original designation. Lower Claiborne of the western Gulf province.

Original diagnosis.—"Protoconch of three smooth and two sculptured whorls, . . . [initial turn] for the most part submerged. Spiral sculpture introduced from the beginning of the fourth whorl; posterior spiral outlining the shoulder . . . Spire terraced, the shoulder a steep ramp . . . axial sculpture confined in the genotype to the earlier whorls; entire surface of conch spirally lirate . . . Outer lip flaring, . . . strongly and closely wrinkled within, from the commissure to the entrance of the anterior canal . . . Anterior canal of moderate length, twisted backward slightly and nasute at its extremity . . . pillar not plicate . . ." (modified after Gardner, 1945, p. 230).

Remarks.—Gardner essentially distinguishes this genus from the very closely allied *Levifusus,* by the larger protoconch of one less turn, the wrinkled inner lip and the absence of a fold on the columella. Powell (1966, p. 145) considered the original placement in the Turridae to be incorrect for much the same reasons that

Wrigley (1939, pp. 281–283) transferred *Surculites* from the Turridae. The genus is restricted to the Eocene.

Michela trabeatoides carinata, new subspecies
Plate 17, figures 15–17

Description.—Whorls six, shoulder smooth or with only faint spiral striae on the early whorls of the spire, later whorls with prominent spiral lines. Spire whorls carinate, the periphery crenulated, with two to three larger lines crowding the carina and crossed by longitudinal folds which run from the uppermost line to the lower suture, retral sinus in the lower third of the shoulder. Suture more deeply impressed than in *Michela trabeatoides* (Harris, 1895a). Body whorl tricarinate, the lowest one faint and rounded. Labrum smooth within; canal longer than in the type and somewhat twisted.

Remarks.—This variety is larger than *Michela trabeatoides* (Harris, 1895a) s.s. that ranges from the Weches through the Cook Mountain formations; the Reklaw form keeps the carination on the body whorl. One large fragment of this species shows no trace of crenules on the body whorl, is strongly bicarinate and covered with spiral lines alternating in size.

Etymology: The name *carinata* (Latin, keeled), refers to the prominent carinated keel on this species.

Type information.—Holotype: PRI 30327; paratype: PRI 30416. Type locality: locality 18.

Material examined.—26 specimens, the largest 30.0 mm length, 17.0 mm width. One large fragment measured ca. 42 mm in width.

Genus **STREPSIDURA** Swainson, 1840, p. 90, 308

Type species.—*Strepsidura costata* Swainson, 1840, by original designation. Eocene of England, France and Belgium.

Original diagnosis.—"Equally fusiform, but the basal portion of the pillar turned inwardly, with a sharp fold at the base of the aperture; shell costated and subcoronated; body whorl ventricose." (Swainson, 1840, p. 308)

Remarks.—The genus is known from the Eocene to Oligocene.

Strepsidura harrisi Givens and Garvie, 1994

?*Bulbifusus inuratus* Conrad. Heilprin, 1891, p. 396 in part (not *Fusus inuratus* Conrad, 1833a, p. 291).

Strepsidura ficus (Gabb). Harris, 1895a, p. 71, pl. 7, fig. 1; Aldrich, 1895, p. 64, pl. 3, figs. 1, 1a

?*Strepsidura ficus* (Gabb). Palmer, 1937, p. 368, pl. 47, fig. 4 (copy pl. 7, fig. 1 in Harris, 1895a).

Strepsidura ficus? (Gabb) or subsp. Palmer and Brann, 1966, p. 922–923 (not *Whitneya ficus* Gabb, 1864, pp. 104, 224, fig. 216).

Strepsidura harrisi Givens and Garvie, 1994, pp. 6–10, pl. 1, figs. 1–6

Original description.—"Shell of medium size, thin-walled, pyriform, with nearly conical spire about one-sixth the total height of the shell and roundly inflated body whorl; whorls about six, including at least four teleoconch whorls, separated by abutting sutures that are slightly sinuous around costae; spire whorls angulate, with uniformly sloping to slightly concave ramp, sculptured by narrow costae overridden by weaker spiral cords; spiral cord midway between sutures enlarged to form shoulder carina, which is noded at intersections with costae; two enlarged cords at posterior margin of whorl form the subsutural collar, which is minutely noded where crossed by costae; costae and shoulder suppressed on side of body whorl but retained on ramp area and neck; growth line profile nearly straight and vertical on side of body whorl, slightly prosocline on ramp area, aperture elongate-oval, sharply constricted anteriorly to form siphonal canal and gradually narrowed posteriorly to form exhalent channel, outer lip thin and smooth within; inner lip with moderately thick parietal and columella callus, which is sharply limited abapically; columella with prominent fold at start of siphonal canal; a second much weaker and apparently vestigial fold is sometimes present posterior to the prominent fold, siphonal canal moderately long, twisted, oblique, deeply notched; siphonal fasciole strong, limited posteriorly by a sharp keel." (Givens and Garvie, 1994, pp. 6–10)

Remarks.—Similar forms occur in the Tejon Eocene of California, in particular from Grapevine Canyon. The Californian forms tend to be a little broader, are slightly more excavated on the shoulder and have weaker ribs. Palmer and Brann (1965, p. 922–923) conjectured that the Californian and Texas species might be conspecific; Givens and Garvie (1994), showed this not to be the case. A very similar species of *Strepsidura* has been found in the Queen City Formation on the Colorado River, Bastrop County, Texas and is now lost. There is also an undescribed species of *Strepsidura* that I have found in the Seguin Formation in Texas.

Type information.—Holotype: UT-TMM 939TX1; paratype: PRI 33114. Type locality: locality 20.

Material examined.—11 specimens, the largest 20.0 mm length, 12.5 mm width.

Family **BUCCINIDAE** Rafinesque, 1815, p. 145

Genus **LAEVIBUCCINUM** Conrad, 1865a, p. 21

Type species.—*Buccinum prorsum* Conrad, 1833b, by monotypy. Eocene, upper Claiborne Group, United States.

Diagnosis.—Protoconch smooth, multispiral with depressed nucleus. Whorls rapidly enlarging, convex, suture deeply impressed. Sculpture of regularly spaced spiral lines. Body whorl large, more than half the total length with short spirally lirate base. Aperture elongate, somewhat emarginate anteriorly, basal notch wide and shallow. Labral profile parasigmoidal, somewhat thickened and lirate. Columella smooth, concave and slightly twisted.

Remarks.—Five species of *Laevibuccinum* are known from the Eocene of the Gulf and Atlantic coastal plains. The genus is restricted to the Paleocene and Eocene of North America.

Laevibuccinum lineatum Heilprin, 1881
Plate 17, figures 7–8

Laevibuccinum lineatum Heilprin, 1881, p. 371, pl. 20, fig. 5. Harris; 1896, p. 97, pl. 9, fig. 15; 1899, p. 52, pl. 6, fig. 12; Palmer, 1937, pl. 44, fig. 3, 4.

Original Description.—"Shell fusiform, of about seven convex volutions which are throughout their whole extent covered by fine but distinct revolving lines; aperture slightly exceeding the spire in length, subcaniculate anteriorly; columella greatly arcuate; outer lip striate within." (Heilprin, 1881, p. 371)

Remarks.—This species ranges from the Midwayan to the Sabinian stage. The primary difference between *L. lineatum* and the type *L. prorsum*, is that the latter has a smooth body whorl midsection. It is interesting that *L. lineatum* is now known to range into the lowest Claiborne strata with no observable change in character.

Type information.—Holotype lost. Lectotype and remaining specimens: ANSP 30554. Type locality: Claiborne Bluff, Alabama River, Alabama. Figured Reklaw specimen: PRI 30412, from locality 4.

Material examined.—114 specimens, the largest: 20.0 mm length, 7.6 mm width.

Genus **EURYOCHETUS** Cossmann, 1896a, p. 35

Type species.—*Buccinum cylindraceum* Deshayes, 1865. Eocene of the Paris Basin.

Diagnosis.—Shell small, thin-shelled, elongate, whorls convex. Protoconch bulbous, multispiral, and not deviated. Whorls convex, fairly rapidly expanding and covered with fine impressed spiral lines. Suture deeply impressed, body whorl very large, about half the length of the shell. Aperture narrow, ending in a short, hardly constricted, truncated canal. Outer lip thin, slightly parasigmoidal, interior smooth. Columella smooth, almost straight with a narrow channel between two weak folds.

Remarks.—This is an uncommon genus which is restricted to the Eocene of Europe and North America. Palmer in Palmer and Brann (1966) doubtfully recognized one species *Laevibuccinum (Euryochetus?) harrisi* (Aldrich, 1897) from Woods Bluff, Hatchetigbee Formation of Alabama, where Aldrich reported it as common. Palmer regarded it as a subgenus of *Laevibuccinum* Conrad, 1865a, but I prefer to give it full generic status following Cossmann and Wenz. *E. punctatum* is easily distinguished from the somewhat similar shaped *Laevibuccinum lineatum* Garvie, n.sp., by the more acute spire, the high multispiral protoconch, the punctate character of the spiral lines, and the obsolete, hardly constricted canal. The genus is restricted to the Eocene of Europe and North America.

Euryochetus punctatum, new species
Plate 16, figures 1–2

Description.—Shell medium in size, slender. Whorls ten, protoconch conical of four and a half whorls, the transition to the adult marked by a low varix. Early whorls rounded, later ones tending to flatten out below the suture. Surface of spire covered with spiral lines, coarse below the suture, punctate and *Acteon*-like over the remainder. The entire surface finely polished and almost glazed. Base of body whorl with large flat-topped spirals. Aperture elongate, notched, outer lip sharp and expanded, edge thickened within and possessing weak posterior lirae. Columella concave, with one very low swelling on the midsection and a weaker one below an almost indistinguishable channel. Anterior canal very short and slightly twisted, basal notch small and shallow.

Remarks.—This shell was very difficult to place and but for the protoconch would have been placed under *Parvisipho* Cossmann, 1889. That genus, which Cossmann includes under his family Chrysodismidae, is part of a group of buccinids with protoconchs having a papillate, deviated nucleus. One other characteristic of *Euryochetus* is the channel between two columellar folds; that character is seen very weakly in *E. punctatum*. So far as I can determine only one other buccinid genus has punctate spiral lines and that is the deep water genus *Charitodoron* Tomlin, 1932, off the coast of South Africa. The main feature distinguishing that genus is the proportionately smaller aperture.

Etymology.—Referring to the ornament of punctate spiral lines.

Type information.—Holotype: PRI 30413. Type locality: locality 4.

Material examined.—One specimen, 23.0 mm length, 8.3 mm width.

Subfamily **PSEUDOLIVINAE** Swainson, 1840, p. 82

Genus **PSEUDOLIVA** Swainson, 1840, p. 82

Type species.—*Buccinum plumbeum* Dillwyn, 1817, by original designation. Recent off the coast of West Africa.

Original Diagnosis.—"Shell thick, oval, oliviform, ventricose; spire very short; base with two parallel grooves, one of which forms a notch at the base of the outer lip; suture slightly channeled; inner lip very thick, and turning inwards; aperture with an internal canal. Connects the Turbinellidae with the Volutidae." (Swainson, 1840, p. 306)

Remarks.—The genus ranges from the Upper Cretaceous to Recent, where is is known by one species from West Africa today.

Pseudoliva cf. **santander** Gardner, 1945
Plate 18, figures 1–3

Pseudoliva santander Gardner, 1945, pp. 195–196, pl. 22, fig. 24; Dockery, 1980, p. 104–105, pl. 3 figs. 1A, 1B, 2, 3A, 3B.

Original description.—"Shell large, rudely conic, the outline obscured by excess callus. Early whorls lost, and characters of adolescent largely concealed by the enveloping body, but probably similar in a general way to that of *P. vetusta* (Conrad). Body relatively large, heavy, broadly inflated, shouldered in the adult; callus thick, deposited along the suture of the final whorl, overtopping the spire in many individuals. Sculpture other than incremental, obsolete or undeveloped even on the area in front of the pseudoliva groove. Aperture relatively short and narrow, obliquely elliptical. Callus pad at posterior commissure thickly spread from the suture to the groove, distorting the posterior portion of the body and the outer lip; a narrow and fairly deep channel between the pad and the labral margin. Pseudolivar groove narrow and deep. Anterior fasciole corrugated by the growth lines, broadly U-shaped terminally. Umbilicus keeled at the margin apparently closed by the reverted callus." (Gardner, 1945, pp. 195–196)

Remarks.—The Reklaw specimens are not as strongly shouldered as in typical *P. santander,* a species from the lower and middle horizon of the Laredo Formation of Mexico, but agree well in the remaining characters. In particular, in the heavy deposit of callus, the oblique elliptical apertural shape, the keeled margin to the umbilical depression, the distinct channel between the outer lip and the labral margin, these specimens match Gardner's species. Of the various races of *Pseudoliva vetusta,* perhaps the Lower Eocene, Woods Bluff and Middle Eocene specimens from the Weches Formation of 14.4 km. E. of Jewett, Leon County, Texas, approach these most closely. With such a variable form the exact placement is to some degree arbitrary, but after examining an extensive suite of material, *P. santander* appears the closest species. Gardner (1934) conjectured that *P. santander* has an umbilicus closed by the callus, but even on the smallest specimens which have very little callus deposit the umbilicus is absent; in any case that feature has not been taken to be of much value in separating the varieties of *P. vetusta.* The best specimen, a juvenile, shows fine ribbing on the first three adult whorls and fine spiral lines on the next whorl. Juvenile and medium-sized specimens have an obliquely compressed form very similar to *Pseudoliva nana* Gardner, 1945. The Reklaw specimens may to some extent be distinguished by their more globose form, by the almost complete effacement of the suture, and by the protractive outer lip. Very similar forms also occur in the Stone City Member of the Cook Mountain Formation, in Rocky Branch Creek, Burleson County, Texas at the base of the formation.

Type information.—Holotype: USNM 497256. Type locality: given as USGS Sta. 13685 (H-9), Los Aldamas, 1.5 km. E. of El Barrio, in San Juan, Nuevo Leon, Mexico (middle part of the Laredo formation). Figured Reklaw specimens: PRI 30418, 30419, from locality 20.

Genus **SIPHONALIA** A. Adams, 1863b, p. 202

Type species.—Buccinum cassidariaeformis Reeve, 1846, by subsequent designation (Cossmann, 1889, p. 149). Recent, seas around Japan.

Diagnosis.—Shell moderate to large in size, low and inflated. Protoconch small and inclined to the axis of the shell. Whorls convex, often ramped and carinate, suture impressed. Sculpture with collabral costae or nodules and fine spiral lines. Body whorl large, the sculpture effervescent towards the base. Siphonal fasciole distinct, canal bent strongly to the left and shallowly notched. Aperture large, ovate, with posterior gutter, outer lip thin, lirate within; columella smooth and excavated.

Remarks.—Wenz (1944) reports the genus widely distributed but with few species. In the Paleogene of the Gulf coastal plain ten species have been described; the genus is also common in the early Tertiary of the Pacific coast. Several species listed by Palmer and Brann (1966) under "*Siphonalia*" do not seem to come close to the type, which is a squat, carinate shell with a strongly bent canal. Cossmann (1901a) lists a number of species of quite variable character under the genus, a range that could include the Gulf Coast species assigned to *Siphonalia.* The genus ranges from the Upper Cretaceous to Recent.

Siphonalia cf. **plummeri** Palmer, 1937
Plate 17, figures 9–10

"Siphonalia" plummeri Palmer, 1937, p. 318, pl. 45, figs. 3, 4; Brann and Kent, 1960, p. 800.

Original description.—"Shell small; whorls rounded, three or four; nucleus of four or five whorls, first two smooth, minute, last three with conspicuous longitudinal ribs; the sculpture of the post-nuclear whorls begins abruptly with a large longitudinal fold and spiral ribs; the surface of the shell is covered with fine spiral threads, with a finer intervening line; there are thirteen, longitudinal folds on an imperfect adult shell; the holotype has nine longitudinal folds but is an immature shell; short anterior canal; labrum crenate within." (Palmer, 1937, p. 318)

Remarks.—The holotype of *S. cf. plummeri* is a juvenile of 7 mm length and 4 mm width and gives a misleading impression of the adult form of the shell; Palmer, (1937, p. 318) notes one of the paratypes has a height of 21 mm. Palmer's species is from the Weches Formation of Texas. The Reklaw species differs from *S. cf. plummeri* in the following minor characters; possessing about one more fold per whorl, being slenderer, and usually lacking the fine intermediate line between the primary spiral lines. These differences seem relatively minor and more material will have to be collected before it is known whether these differences are constant.

Type information.—Holotype: PRI 3092. Type locality: Colorado River at Smithville, Bastrop County, Texas. Figured Reklaw specimen: PRI 30420, from locality 20.

Superfamily **VOLUTOIDEA** Rafinesque, 1815, p. 19

Family **VOLUTIDAE**, Fleming, 1822, p. 490

Subfamily **ATHLETINAE** Pilsbry and Olsson, 1954, p. 15

Genus **VOLUTOCORBIS** Dall, 1890, p. 75

Type species.—Volutilithes limopsis Conrad, 1860, by original designation. Paleocene, Porter's Creek Formation of Alabama.

Diagnosis.—Shell resembling *Volutilithes*, but more slender and without a coronated shoulder; the sculpture is reticulate, and nodose or prickly at the intersections; the sutural sinus is less evident than in *Volutilithes*, and the suture is sometimes channeled.

Remarks.—According to Rehder (1969) the genus ranges from the Paleocene to Recent. Four members of the species are recognized today, all from deep water off the South African coast. Specimens of *Volutocorbis* are generally uncommon in fossil deposits, except paradoxically in the Reklaw, where they are abundant.

Volutocorbis stenzeli (Plummer, 1933)

Plate 18, figures 14–15

Plejonia (Volutocorbis) stenzeli Plummer, 1933, p. 813, pl. 9, figs. 12, 13

Volutocorbis stenzeli Plummer. Palmer, 1937, p. 384, pl. 59, figs. 1, 2, copies Plummer.

Diagnosis.—First three whorls smooth, next two ribbed, remainder cancellate. 40 longitudinal ribs on the body whorl; transverse ribs about equal in strength to the longitudinal ribs. Apical angle 64°, altitude 20 mm, maximum diameter 10 mm. (After Plummer, 1933, p. 384)

Revised Description.—Whorls seven and a half, protoconch of three and a half smooth whorls, the first minute and almost flush with the next. Adult sculpture starts with two longitudinal costae followed half a whorl later by two transverse ribs at the upper and lower sutures; these are nodular where they cross the longitudinal ribs. At about whorl five a medial fine transverse line develops which rapidly increases in size to become another rib. Later whorls develop further transverse ribs above the lower suture so that the penultimate whorl has four large nodular ribs. Transverse ribs are larger than the longitudinal ones; body whorl crossed by about 23 longitudinal ribs and minute growth lines, two to three columellar folds present, callus visible as a thin wide deposit, outer lip with 13 tubercles.

Remarks.—Some specimens develop the third and fourth longitudinal ribs in the reverse order. Some specimens show a smaller superior columellar fold. Apical angle varies between 60° and 65°. *Volutocorbis limopsis* (Conrad, 1860) has a similar protoconch, equally sized spiral ribs, and vertically flattened tubercles. The longer aperture and straighter spire profile of the Reklaw specimens are very distinctive. The genus persists in Texas until at least the upper Cook Mountain Formation (Landrum and Wheelock members) as the author has a few specimens from Alabama Bluff, Trinity River, and from the Little Brazos River, Texas. *V. stenzeli* has only been found in the Marquez Member in Milam, Bastrop, and Caldwell Counties, Texas.

Type information.—Syntypes: Plummer collection, TBEG P5381, P14165. Type locality: TBEG 28-T-9, dump at the site of old Copper prospect, 4.5 miles NE of Harwood, Caldwell Co., Texas. Figured specimen: PRI 30421, from locality 20.

Material examined.—250+ specimens, the largest: 16.0 mm length, 7.5 mm width.

Genus **ATHLETA** Conrad, 1853b, p. 449

Type species.—Voluta rarispina Lamarck, 1811, by subsequent designation (Dall, 1890, p. 75). Miocene of Europe.

Diagnosis.—Shell fusiform, spire about one-fifth to one-third the height of the shell. Smooth protoconch of one and a half to four and a half whorls followed by a ribbed stage of a half to a quarter whorl and a cancellate stage between one to one and a half whorls. Teleoconch shouldered, longitudinally costate or ribbed, often spinose at the shoulder; below the shoulder the spiral lines are numerous. Aperture ovate, inner lip with two to three folds, outer lip often denticulate, siphonal canal wide, shallow, slightly recurved, beak long.

Remarks.—The genus is known from the Eocene to Miocene.

Athleta petrosus smithii Fisher and Rodda, 1964

Plate 18, figures 6–9

Athleta petrosus smithii Fisher and Rodda, *in* Fisher, Rodda and Dietrich, 1964, p. 43 +, pl. 8, figs. 8, 9; pl. 11, figs. 1–5

Athleta petrosus smithii Fisher and Rodda. Palmer and Brann, 1966, p. 515–516.

Original description.—"Shell small, medium-sized, whorls eight to ten, protoconch two and seven-eighths to four and a quarter smooth whorls, next quarter to half with longitudinal riblets. Later whorls with a noded shoulder and a noded subsutural ridge, the two separated by a poorly defined ramp. On the larger specimens the shoulder nodes increase in size to become small transversely-pointing spines which are at the termination of low longitudinal folds. Body whorl rounded in small specimens, straight in larger ones, beak sharply constricted into a spirally lirate neck. Aperture straight, obliquely inclined, two columellar folds, slight siphonal fasciole present." (Fisher and Rodda, *in* Fisher, Rodda and Dietrich, 1964, p. 43)

Remarks.—200 specimens were used to measure various characters such as length, spire angle, diameter/length, number of columellar folds, etc. and these noted for each specimen and plotted graphically. Despite the fact that two intermixed species of *Athleta* seemed to be present, no consistent set of characters could be found to reliably separate the groups. The species displays a wider variation of characters than is indicated in Fisher *et al.* (1964); in particular when the number of ribs on the body whorl is plotted against the length, the specimens generally separate into two groups for large specimens and overlap for the smaller ones. The first variety displays the typical profile of *Athleta petrosus* (Conrad, 1833a) s.s. from the Weches through the Gosport Sand formations, with the upward pointing spines, a spire angle of 58°–65° and usually a moderate to heavy amount of callus deposit from whorl seven onwards. The other group tends to have a more subdued profile, a spire angle of 51°–60°, a smaller shoulder ramp, cancellate ornament and missing or weak folds or spines. No consistent set of characters could be found in either the juvenile specimens or the spire of the adult specimens which could consistently distinguish the two groups throughout all stages of growth. In the first group, the adult spinose sculpture may develop in specimens as small as 15 mm and is present in all specimens of 20 mm or larger. About 60% of all specimens have a moderate amount of callus deposit, 20% showing prominent denticles on the outer lip. These characters are not dependent on the growth stage of the specimen, being displayed on specimens as small as 5 mm. For very small specimens of 5–7 mm, or four to five whorls, a separation into two stocks is again apparent; those with a high protoconch of three and a half to four whorls, coarse longitudinal folds and lack of transverse lirae on the body whorl, and those with a more squat protoconch of three and an eighth to three and three-quarters whorls, shoulder rarely present and a more uniform cancellate ornament. The high protoconch group can be correlated with the spinose adult form but only in general terms. It is possible that these specimens contain two species, the descendants of the stocks of *Athleta tuomeyi* Conrad, 1853b from the Paleocene and Lower Eocene, and *Athleta petrosus* (Conrad, 1833a), that have not become sufficiently differentiated to separate them taxonomically. Alternatively this might be a case of sexual dimorphism.

Type information.—Holotype: TBEG 35288. Type locality: bluff on Ridge Creek, 6.2 m. West of Smithville, Bastrop County, Texas; locality 6 (=TBEG locality no. 11-T-7). Figured specimens: PRI 30422–30424, from locations 20.

Material examined.—400+, the largest 34 mm length, 19 mm width, spire angle 57°–73°.

Family **HARPIDAE** Bronn, 1849, p. 469

Genus **CRYPTOCHORDA** Mörch, 1858, p. 43

Type species.—*Buccinum stromboides* Hermanns, 1781, by monotypy. Eocene of England and France.

Diagnosis.—Shell fusiform, not high, smooth. Protoconch rounded with four smooth whorls. Whorls rounded, body whorl large and inflated, basally constricted to a short neck, siphonal fasciole weak. Aperture elongate with posterior gutter, anterior notch deep. Outer lip thickened, almost straight. Columella without folds, curved several times, anteriorly reaching below the labrum, columellar callus thinly covering the ventral surface and most of the spire.

Remarks.—The genus is relatively rare and restricted to the Paleogene of North America and Europe. Four Claibornian species are known and one from the Eocene of California.

Cryptochorda? sp.

Plate 18, figure 16

Remarks.—Several fragments of the outer lip of a *Cryptochorda* were obtained, all of them associated with a large mass of worn coral. The differences between this species and other Claibornian ones indicate a less robust species with a thinner spread of enamel. The base of the body whorl has five to seven impressed spiral lines, a feature also seen in some specimens of *Cryptochorda eureia* Stenzel and Turner, 1940, from the Weches Formation of Texas.

Material examined.—Five fragments, the largest 25 mm length, comprising the lip and part of the body whorl, from locality 20. Figured specimen: PRI 33129.

Family **OLIVIDAE** Latrielle, 1825, p. 198

Genus **ANCILLA** Lamarck, 1799, p. 70

Type species.—Voluta ampla Gmelin, 1791, by monotypy. Living in the Indo-Pacific.

Diagnosis.—Shell elongate, ovoid-fusiform; sutures usually externally covered with callus; surface smooth, often polished. Aperture long, broader anteriorly, with a slight anterior notch, outer lip sharp, smooth within; columella slightly twisted, with fine folds; anterior part of the aperture with a callus deposit.

Remarks.—Wenz (1943) lists *Ancilla* ranging questionably from the Cretaceous (Senonian) to recent. The genus is well known, and common in the Sabinian and Claibornian stages of the Gulf coastal plain. The genus s.l. is ranges from the Upper Cretaceous to Recent.

Subgenus **OLIVULA** Conrad, 1832b, p. 25

Type species.—Ancilla (Olivula) staminea (Conrad, 1832b), by subsequent designation (Cossmann, 1899b, p. 70). Sabinian and Claibornian stages of the southeastern United States.

Diagnosis.—Shell medium to large in size; elongate, spire short; suture somewhat channeled; subsutural collar heavy, covered by callus that extends over the upper margin of the preceeding whorl; aperture very long, somewhat expanded anteriorly; outer lip straight or weakly convex, posteriorly abruptly bent towards the body. Ancillid band broad, fasciolar band divided into two bands by a spiral line; fasciolar groove deep.

Remarks.—Olivula is an Eocene genus restricted to North America.

Ancilla (Olivula) staminea reklawensis, new subspecies

Plate 19, figures 15–16

Description.—Shell medium in size, elongate, weakly inflated; spire whorls covered with a thin even coat of callus which spreads from the apertural region to the previous or earlier whorl; collar with a groove on the upper third to one quarter; sculpture of very subdued ornamentation of longitudinal lines and spiral striae.

Remarks.—Lower Eocene forms of *Ancilla (O.) staminea* have a thick development of the callus and only one groove in the anterior enamel band; the body whorl ornamentation is very similar to that of Middle Claibornian forms of *A. (O.) staminea*. The labial development of the Reklaw subspecies is more closely allied to the middle Eocene representatives of *A. (O.) staminea*, which have two grooves on the enamel band, more prominent body whorl ornamentation and a higher and less callus covered spire. Specimens of *A. (O.) staminea* from St. Maurice, Louisiana show the greatest similarity to the Reklaw material.

Etymology.—Referring to the formation.

Type information.—Holotype: PRI 30425; paratype: PRI 30426. Type locality: locality 20.

Material examined.—225 specimens, the largest: 17.4 mm length, 6.2 mm width.

Superfamily **CANCELLARIOIDEA** Gray, 1853, p. 130

Family **CANCELLARIDAE** Forbes and Hanley, 1853, p. 360

Genus **ADMETULA** Cossmann, 1889, p. 224

Type species.—Cancellaria evulsa (Solander, 1776), by original designation. Bartonian Eocene of England.

Diagnosis.—Shell inflated, not umbilicated, with varices and cancellate ornament; protoconch paucispiral, prominent, flattened; aperture oval, outer lip lirate within corresponding to the last varix; beak slighty twisted and bent to the left, not notched; labial deposit thin; columella with three oblique folds, the lowest weaker and not as oblique as the upper two.

Remarks.—The genus is known from the Upper Cretaceous to the Pliocene.

Admetula irregularis, new species

Plate 19, figures 1–2

Description.—Shell small and squat, of five and a half whorls. Protoconch of two and a half smooth rounded whorls, nucleus minute, transition to final adult sculpture is via a cancellate ornament of a quarter whorl. Adult sculpture of 12 to 13 oblique costae which vary irregularly in size from thin raised lines to thick varices, these are overridden by five spiral lines on the spire and 11 or 12 on the body whorl, the intersections with the smaller costae nodular. Whorls strongly contracted at the suture making the sutural diameter less than that of the previous whorl. Aperture ovate, outer lip curving smoothly to the base and lirate within. Columella with plications, the two uppermost stronger and terminating abruptly abaperturally, the lower plication marking the start of a short unnotched canal. Edge of inner lip margining a deep depression.

Remarks.—Two similar species are *Admetula tortiplica* (Conrad, 1865a) and *Admetula parilis* (Palmer, 1937), both from the Middle Claibornian. *A. tortiplica* is more elongate and has one more spiral line on the spire and the columellar plications develop gradually from the two uppermost revolving ribs; *A. parilis* is shorter, has stronger spiral lines and has weaker varices. All the specimens at hand are probably juvenile but are still readily distinguished by the smaller size and irregular ornamentation; the largest specimen (the holotype) has a medial spiral thread between spiral lines on the body whorl. Several similar Cancellaridae from the Claibornian have a similar irregular sculpture but none so pronounced as *A. irregularis.*

Etymology.—Referring to the irregularly sized costae.

Type information.—Holotype: PRI 30427; paratypes: PRI 30428. Type locality: locality 4.

Material examined.—15 specimens, the largest 4.5 mm length, 2.8 mm width.

Genus **TRIGONOSTOMA** Blainville, 1827, p. 652

Type species.—Delphinula trigonostoma Lamarck, 1822, by monotypy. Recent in the Indo-Pacific.

Diagnosis.—Shell globose to high, whorls more or less loosely wound; shoulder wide and concave; aperture trigonal and bent to the right; widely umbilicate, siphonal fasciole strong; columella with two or three plications.

Remarks.—Genus *Trigonostoma* ranges from the Lower Eocene to Recent. Recent species of the genus are temperate to tropical in distribution.

Subgenus **VENTRILIA** Jousseaume, 1887, p. 194

Type species.—Ventrilia ventrilia Jousseaume, 1887 (= *Cancellaria tenera* Philippi, 1848), by monotypy. Recent, in the Caribbean.

Diagnosis.—Whorls carinate, closely coiled, suture channeled or deeply impressed, the diameter less than the carina of the previous whorl; umbilicus well developed, margined by a broad siphonal fasciole; peristome continuous, channeled below; columella concave with two weak folds, partially resorbed at umbilical edge.

Remarks.—Ventrilia is known from the Eocene to Recent.

Trigonostoma (Ventrilia) herbae, new species
Plate 19, figures 3–4

Description.—Shell small, slender for the genus. Protoconch of two and a half smooth whorls, flattened at the apex, nucleus minute, last nuclear whorl greatly expanded. Adult sculpture up to five and a half smooth convex whorls which carry microscopic widely spaced spiral striae, slightly more prominent on the lower part of the whorls. Shoulder prominent, smoothly concave, the keel thickened and with 12 to 14 bladelike costae on each whorl, the upper ends of which are rounded, bent back and projecting well above the shoulder; on the shoulder the upper ends of the costae meet the suture almost tangentially. Aperture ovately triangular, inner lip with two columellar folds that are margined below by a swelling on the columella, labrum with obscure denticles, umbilicus small.

Remarks.—A few specimens have the costae thickened to such a degree that they can be considered varices. The nearest relatives are *Trigonostoma panones* (Harris, 1895a) from the Weches Formation, and *Trigonostoma sabinetownensis* LeBlank, 1942 from the Hatchetigbee Formation. Unfortunately the holotype of *T. sabinetownensis* is lost; based on the published figures and text by LeBlank; *T. sabinetownensis* has sharp costae, is smaller, and has only two columellar folds, while *T. panones* has three columellar folds, thickened costae that are nodular above the keel, and is altogether a broader shell. In *T. (V.) herbae* the costae and growth lines on the shoulder meet almost tangentially while in *T. panones* they meet at ca. 45°. *Trigonostoma gemmatum* (Conrad, 1833a), a more distantly related species, also has the costae meeting the suture almost tangentially. The high spire of this species and lack of strong spiral ornament place this species rather doubtfully in *Ventrilia;* most American Eocene cancellarids require a revison for proper placement but that is outside the scope of this report.

Etymology.—The name *herbae* (Latin, blade), refers to the blade-like costae.

Type information.—Holotype: PRI 30429; paratypes: PRI 30430, 30431. Type locality: locality 20.

Material examined.—92 specimens, the largest: 8.5 mm length.

Trigonostoma (Ventrilia) elegantissima, new species
Plate 19, figures 7–8

Description.—Shell small, slender, of up to six and three-quarter whorls. Protoconch of two and a half to two and three-quarter smooth inflated whorls, nucleus minute. Adult whorls with 17 to 21 strong costae, fluted above and projecting a little above the convex shoulder. About six spiral ribs on the spire and 11 on the body whorl. Sharp prominent nodes are developed where the spiral ribs cross the costae. Aperture triangular, labrum with seven denticles, inner lip with two folds, a denticle on the lower margin and above with two spiral rows of denticles on the callus corresponding in position to the nodes beneath. Length of umbilical area more than half the apertural length.

Remarks.—This species has affinities with *Trigonostoma panones smithvillensis* (Harris, 1895a), *Trigonostoma panones juniperum* (Harris, 1895a) and *Trigonostoma penrosei* (Harris, 1895a), and may be ancestral to all of them. *T. penrosei* also has nodular ribs, but three plications on the columella, 10 to 11 ribs and three spiral lines. Unfortunately the holotype of *T. penrosei* is so damaged that only the published figures can be relied upon. Both *T. harrisi* and *T. juniperum* have an obtuse shoulder angulation, but not as acute as in *T. (V.) elegantissima,* and both have a different apertural profile. The distinctive features of *T. (V.) elegantissima* are the concave profile of the lower portion of the body whorl and the very crisp and nodular ornamentation.

Etymology.—The name *elegantissima* (Latin, most elegant), refers to the very elegant form of this species.

Type information.—Holotype: PRI 30432. Type locality: locality 20.

Material examined.—Nine specimens, the largest: 9.0 mm length.

Trigonostoma (Ventrilia) jonesae, new species
Plate 19, figures 5–6

Description.—Shell small, whorls seven, protoconch of two smooth whorls, the apex flattened and the nucleus depressed and minute. Adult whorls with a rounded shoulder and 14 to 15 costae per whorl of which four per whorl are developed into varices. Whorls crossed by numerous irregularly spaced spiral lines tending to become obsolete above the carina. On the body whorl the ribs are smaller, regularly spaced and crossed at right angles by low undulations on the umbilical margin, the undulations formed by the posterior end of the thickened longitudinal costae. Aperture suboval, labrum thickened within and with seven spiral lirae. Inner lip with two folds and a lower crenulation. Umbilicus small.

Remarks.—The closest relative to this species is *Trigonostoma panones smithvillensis* (Harris, 1895a) from the Weches Formation, but that species has no secondary sculpture, has a more rounded shoulder and keel, and a very much larger protoconch. *T. (V.) jonesae* combines characters common to species of both *Sveltia,* Jousseaume, 1887, and *Trigonostoma. Sveltia alveata* (Conrad, 1833b) from the upper Claiborne Group, of which *T. (V.) jonesae* is a probable ancestor, has a similar shape, protoconch and body whorl ornamentation, but the ornament of the spire is more regular in shape and shows none of the varices characteristic of the Reklaw species. *Trigonostoma* s.s has a channeled suture and a triangular aperture, the base of which is a posterior gutter placed well away from the suture and is reflected to the right. Species of *Sveltia* s.s. have an obliquely elongated aperture, impressed sutures and a flaring outer lip. In *T. (V.) jonesae* the lip is moderately flaring, the base is reflected and an impressed suture is contained within a weak gutter. Most species assigned to *Trigonostoma* in the Claibornian Eocene do not have the base of the aperture reflected to the left, or the channeled sutures typical of that genus.

Etymology.—This species is named in honor of Dr. Carol Jones, formerly of the Academy of Natural Sciences, Philadelphia.

Type information.—Holotype: PRI 30433; paratype: PRI 30434, a juvenile. Type locality: locality 20.

Material examined.—Five specimens, the largest: 10.0 mm length.

Family **MITRIDAE** Swainson, 1831, pls. 49, 50, 54[14]

Subfamily **CYLINDROMITRINAE** Cossmann, 1899, p. 152

Genus **VOLVARIELLA** Fisher, 1883, p. 553

Type species.—Volvaria lamarcki Deshayes, 1865, by monotypy. Eocene of the Paris Basin.

Diagnosis.—"Shell small, 7–15 mm, cylindrical and slender, spire short and conical, with almost five whorls; nuclear whorls are smooth and flat. Sculptured with numerous and finely punctate spiral striae. Aperture longer than the spire, straight, slightly flaring anteriorly; columella with 2 anteriorly placed folds." (Cernohorsky, 1970, p. 64).

Remarks.—Cernohorsky (1970), stated that the genus *Volvariella* is probably related to *Cylindites* J. de C. Sowerby, 1824, a genus within the family Acteonidae. As one characteristic of the opisthobranch family Acteonidae is a heterostrophic nucleus, a specimen of *Volvariella milamensis,* n. sp. was carefully broken and the nucleus examined. The nucleus was found to be dextral and in fact quite similar to that of *Ancilla* Lamarck, 1799. On this evidence the genus is kept within the Mitridae where it had been placed by previous authors. The genus is restricted to the Eocene of Europe and North America.

Volvariella milamensis, new species
Plate 19, figures 11–12

Description.—Protoconch of two and a half to three whorls, loosely coiled. Whorls three through six are partially immersed in the later whorls. Body whorl punctate, columella with three folds and above that a swelling that dies out as it revolves into the aperture. The first and third folds continue revolving into the aperture while the second becomes obsolete and merges into the upper one. Spire angle of 77° to 90°.

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[14] *Nomen transl.* Adams, A. and Adams, H. 1853 (*ex* Mitranae)

Remarks.—This species is similar to *Volvariella gabbiana* Harris, 1895a, and could have been assigned there but for the larger number of columellar folds, its spire angle of 115° and its non-punctate surface. Another species related to this one is *Volvariella reticulata* Johnson, 1899; its spire angle is ca. 60°. Two specimens show traces of violet color banding collabral with the growth lines.

Etymology.—The specific name refers to the occurrence in Milam County.

Type information.—Holotype: PRI 30435; paratypes: PRI 30436, 30437. Type locality: locality 20.

Material examined.—17 specimens: the largest 10.0 mm length, 3.0 mm width.

Superfamily **CONOIDEA** Rafinesque, 1815, p. 19

Family **CONIDAE** Rafinesque, 1815, p. 19

Genus **CONUS** Linneaus, 1758, p. 712

Type species.—Conus marmoreus Linneaus, 1758, by subsequent designation (Children, 1823). Recent in the Indo-Pacific.

Diagnosis.—Shell usually solid, thick-shelled, in the form of an inverse cone with straight or concave sides. Spire usually low, later whorls enveloping earlier ones below the suture, ornament above smooth or with rows of nodules, below with spiral lines. Siphonal fasciole strong, smooth or with spiral lines. Aperture thin, elongate, parallel, sometimes a little wider anteriorly, extending most of the length of the shell. Outer lip thin, sharp, top with anal sinus. Columella straight, posterior gutter present, earlier whorls partially resorbed.

Remarks.—Conus s.s. is known from the Pliocene to Recent. The genus is primarily tropical in distribution.

Subgenus **LITHOCONUS** Mörch, 1852, p. 66

Type species.—Conus millepunctatus Lamarck, 1822, by subsequent designation (Cossmann, 1889, p. 232). Recent in the Indo-Pacific.

Diagnosis.—Shell moderate to large in size. Spire concave to flat, or very low. Protoconch globular, with blunt nucleus. Above the shoulder, whorls weakly concave, smooth or with fine spiral striae; sutures impressed. Below shoulder, body whorl smooth, basally with spiral lines, and wide impressed anal depression, siphonal fasciole present. Aperture wider below. Anteriorly weakly notched. Outer lip prosocyrt.

Remarks.—Wenz (1943) gives the range of *Lithoconus* questionably from the Cretaceous (Senonian), to Recent.

Conus (Lithoconus) nocens, new species
Plate 19, figures 9–10

Description.—Shell small, protoconch of two and one-half smooth whorls. Spire whorls with five or six spiral lines. Below the carina early whorls ornamented with weak oblique nodules, later ones smooth. Body whorl a straight cone, smooth, base with strong punctate, crowded spiral lines. Columella terminated with a strong, very oblique fold, siphonal fasciole weak.

Remarks.—Four characters in combination serve to distinguish this species from *Conus (Lithoconus) sauridens* Conrad, 1833b, the common cone from the Cook Mountain Formation: the flat sides, the sharp unridged carina, the coarse, strong, spiral basal lines, and the lack of strong growth lines on the ramp. The growth lines on Cook Mountain specimens generate a characteristic reticulated pattern on the ramp where they cross the spiral lines. As Palmer (1937, p. 461) has already noted, the height and shape of the spire in this species is so variable as to preclude use of that feature in a definite determination. I have a large collection of cones from the Weches Formation where the common species is also referred to *C. (L.) nocens*. These specimens show a slightly rounded carina, giving the whorl profile a weakly sinuous profile but still far closer to the type than is *C. (L.) sauridens*. The largest Weches specimens of *C. (L.) nocens* tend to have obsolescent basal spiral lines on the abapertural side but keep them adaperturally. Larger Cook Mountain specimens of *C. (L.) sauridens* develop a strong, swollen siphonal fasciole, whereas *C. (L.) nocens* does not. The systematics of the Middle Claibornian cones is badly in need of revision; at least another three well characterized species can be recognised aside from *C. (L.) sauridens*.

Etymology.—The specific name is a play on the type locality, "Devil's Eye".

Type information.—Holotype: UT-TMM 84822; paratype: UT-TMM 84823. Type locality: locality 11. Holotype length, 20.0 mm.

Material examined.—Two Reklaw specimens, 25 Weches specimens, 100+ Cook Mountain specimens.

Family **TURRIDAE** H. and A. Adams, 1858, p. 614[15]

Subfamily **TURRICULINAE** Powell, 1942, p. 29

Genus **TURRICULA** Schumacher, 1817, p. 217

Type species.—Turricula flammea Schumacher, 1817, by monotypy. Recent from the Indo-Pacific.

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[15] Swainson (1840) has been credited with the definition of the name Turridae although he uses the name Pleurotomidae. H. and A. Adams (1858) use Turrinae in the first page of the index of volume 1 to refer to Turritidae and Turritinae on p. 87. On p. 246, they note a new suborder established by Dr. Gray on the basis of anatomical characters; in volume 2, p. 614, the names Turridae and Turrinae are formally established.

Diagnosis.—Shell fusiform, usually shouldered, carinate, with a long, straight or slightly bent, narrow canal. Sculpture varying from smooth to strong spirals, often nodular where crossed by growth lines. Protoconch of two to two and one-half smooth whorls. Anal sinus on the shoulder slope, moderately deep, wide and U-shaped; outer lip thin.

Remarks.—Powell (1966) has *Turricula* ranging from the Eocene to Recent. *Turricula* s.l. appears to occur in the Upper Cretaceous of the Gulf Coast.

Turricula sp.

Plate 19, figures 13–14

Description.—Shell small, moderately inflated. Whorls with subsutural collar, concave ramp, jutting carina and constricted below; body whorl broadly rounded. Ornament of numerous spiral lines; with weak folds below the carina on early whorls; elongated riblets on the subsutural collar generated by the growth lines, stronger on later whorls. Columella straight and smooth.

Remarks.—The one specimen found of this genus is missing the protoconch, and part of the outer lip and canal. Palmer and Brann (1966) list five species of *Turricula* from the Paleocene and Eocene of the Gulf Coastal Plain; none of these shows much similarity to the present species. This species is remarkably similar to *Turricula planetica* (Edwards, 1856), from the Eocene Bracklesham and Barton beds of southern England, and can be distinguished from that species by the lower position of the carina, the more prominently defined collar, and the noded character of the whorls below the carina on the early whorls.

Material examined.—One specimen, 22 mm length. Location 20, unit F. Figured specimen: PRI 30560.

Genus **SURCULOMA** Casey, 1904, p. 153

Type species.—Pleurotoma tabulata Conrad, 1833b, by original designation. Middle Eocene, Gosport Sand Formation of Alabama.

Original diagnosis.—"... the small paucispiral embryo is very nearly the same in general form [to *Amblyacrum,* Cossmann, 1889] ... In *Surculoma* the beak is rather slender and somewhat abruptly formed below the convexity of the body whorl, the ribs large and few in number, the spire whorls always more or less angulate in profile at the periphery and the sculpture invariably consists of minute and very close-set spiral lines." (Casey, 1904, p. 153)

Subgenus **VOLUTAPEX**, new subgenus

Type species.—Surculoma calantica Harris, 1937, herein.

Diagnosis.—Shells like *Surculoma* but with a bluntly mammilate nucleus, spiral striation most obvious anteriorly. Ribbing typically having a vertically pinched appearance, thus producing whorls or a more or less carinated aspect. (after Harris, 1937, p. 55)

Remarks.—Harris (1937, p. 55) proposed *Volutapex* as a section of *Surculoma*; the latter taxon defined as a subgenus of *Turricula,* and thus *Volutapex* had then no formal taxonomic status. Palmer and Brann (1966) use *Volutapex* as a subgenus and list eight species under that taxon, but do not give a diagnosis or figure of the type species so the taxonomic status remained unchanged. Powell (1966) briefly discusses *Volutapex* but does not believe it deserves more than sectional significance. In my experience, the Claibornian species assigned to *Volutapex* form a natural group and should be given more than sectional status. Harris, 1937, notes *Surculoma calantica* Harris, 1937, may be regarded as typical and includes four other species in the section; the Reklaw species described in the next section fits readily in Harris's group. The group appears restricted to the Eocene of the Gulf Coast.

Surculoma (Volutapex) imbricata, new species

Plate 20, figure 14

Description.—Shell medium sized, elongate fusiform. Whorls ten, protoconch obtuse, blunt and mammillate, of one smooth volution; the remaining whorls strongly carinate and possessing a sharp keel. Shoulder concave with indications of a faint subsutural collar, profile convex below the keel, six to eight longitudinal folds per whorl, strong below and fading out below the collar. Surface ornamented with numerous close-set, sharp, collabral striae and irregular, spiral lines, both obsolescent on the shoulder; below the keel a few stronger spirals. Where the spiral lines cross the longitudinal ones a minute muricate ornament is developed that is stronger on the shoulder. Base of the body whorl with stronger spiral lines which alternate in size on the beak. Aperture ovate, outer lip sharp, incurved and smooth within. Columella long and slightly twisted, siphonal fasciole variable in strength. Umbilical depression usually present.

Remarks.—The strength of the siphonal fasciole is quite variable; thin-shelled specimens have a very weak fasciole and almost no umbilical depression, thicker specimens have a prominent, strongly twisted fasciole, and a larger depression; in one case the umbilical depression is developed into a small false umbilicus. A close representative is *Surculoma penrosei* (Harris, 1937). The Reklaw specimens have a more prominently imbricated ornament, much more angular whorls, a concave shoulder and are generally shorter.

Etymology.—The specific name *imbricata* notes the imbricate character of the whorls.

Type information.—Holotype: PRI 30460; paratypes: PRI 30461–30463. Type locality: locality 20.

Material examined.—140 + specimens, the largest: 28.0 mm length, 10.3 mm width.

Genus **LYROSURCULA** Casey, 1904, p. 156

Type species.—*Lyrosurcula elegans* Casey, 1904, by subsequent designation (Powell, 1942, p. 16). Claibornian Eocene of the United States.

Diagnosis.—Shell with multispiral conical protoconch, initially smooth then with widely spaced arcuate riblets. Teleoconch whorls with large fasciolar surface, spirally lirate throughout, with axial ornament of angular, large, barely inflated costae separated by regular depressions that are strong below the fasciolar surface, and weak or obsolete above. Aperture and canal long, columella straight and smooth.

Remarks.—The teleoconch sculpture is very distinctive but usually poorly described. A common character of shells is a regular arrangement of nodes, or spines, superimposed on a regularly conical spire; the genus *Lyrosurcula* has an unusual arrangement where regularly arranged, radially depressed areas, or dimples, are seen instead of nodes or spines. The genus is known only from the Eocene of the Gulf Coast.

Lyrosurcula cf. **vaughani** (Harris, 1895a)
Plate 20, figures 16–17

Pleurotoma vaughani Harris, 1895a, p. 57, pl. 4, fig. 8.
Lyrosurcula vaughani (Harris). Casey, 1904, p. 157; Harris, 1937, p. 82, pl. 13, fig. 38; fig. 39; Brann and Kent, 1960, p. 516; Palmer and Brann, 1966, p. 746.

Remarks.—Two juveniles are assigned to this species. *L. vaughani* ranges from the Weches Formation to the Upper Cook Mountain Formation. The only differences observed are the more pointed protoconch and generally sharper spiral ornamentation of the Reklaw specimens. More material will have to be discovered before it can be determined whether these differences are significant or not.

Type information.—Holotype: TBEG 35616, from the Weches Formation. Type locality: banks of Colorado River at Smithville, Bastrop County, Texas. Figured Reklaw specimen: PRI 33130.

Genus **PYRAMIMITRA** Conrad, 1865a, p. 28

Type species.—*Mitra terebraeformis* Conrad, 1848, by monotypy. Gosport Sand Formation of Alabama.

Diagnosis.—Shell small, slender. Protoconch multispiral, initially smooth, later longitudinally costate, nucleus small. Whorls feebly convex, with impressed suture and longitudinal ribs and spiral lines. Body whorl one-third to one-half the total height, convex and with short neck. Aperture small, canal short and bent. Columella short, straight, with one to two folds.

Remarks.—The genus is known from the Eocene and Oligocene of North America and Europe.

Subgenus **PETRAFIXIA** Cossmann, 1901b, p. 127

Type species.—*Fusus koeneni* Cossmann and Lambert, 1884, by monotypy. Estampes Oligocene of France.

Diagnosis.—Shell very small. Body whorl about one-half of the total height. Outer lip thin, smooth inside. Columella with one fold at the beginning of the canal.

Remarks.—To date *Petrafixia* is known only from the Oligocene of Europe

Pyramimitra (Petrafixia) eocenica, new species
Plate 20, figures 8–9

Description.—Shell very small, slender. Whorls six and one-half to seven; protoconch of three and one-half whorls, the first two and one-half smooth, rounded and with a subsutural line, the last with well developed longitudinal riblets. Adult whorls smooth and polished, sculptured with six longitudinal ribs per whorl and three spiral lines of about equal strength, one below the suture and two in the mid-section of the whorl, the ribs more prominent where they cross the ribs. Some specimens have a fine, intermediate spiral stria below the subsutural line. Occasionally a fourth rib is uncovered by the succeeding whorl. Suture moderately impressed, becoming strongly so by the final whorl; growth lines widely arcuate with the base of the sinus on the second line. Body whorl with seven or eight spiral lines and six or seven more on the base. Aperture elliptical, outer lip thin, smooth within; columella very short and straight, sharply terminated on the left and bounded below by a very weak fold. Canal short, twisted and bent to the left.

Remarks.—This species is easily distinguished from its closest relative *Pyramimitra terebraeformis* (Conrad, 1848), by the differing spiral sculpture and the lack of two columellar plications. Conrad (1848), originally places *P. terebraeformis* under *Mitra*, due no doubt to its mitrid proportions and strong columellar folds; in 1865 he creates the monotypic genus *Pyramimitra* for it. In 1901b Cossmann creates the family Pyramimitridae to include *Pyramimitra* s.s. and one subgenus *Petrafixia.* Excepting Wenz (1943), who places it in the Buccinidae; other authors, viz. Palmer (1937), Harris and Palmer (1946), Palmer and Brann (1966), and Dockery (1977), follow Cossmann in his placement. Cossmann (1901b, p. 125) gives a synopsis of what he regarded as the evolution of *Pyramimitra* in which *Petrafixia* is the evolutionary descendant of

Pyramimitra s.s. in a line which terminated in *Pisanella* Koenen, 1865. It appears more probable that *Petrafixia* is the ancestor and the Oligocene species *P. (P.) koeneni* in France is a separate offshoot. I have collected specimens of a *Pyramimitra* from the Weches Formation at Burleson Bluff, on the Brazos River, which are intermediate in character between *P. (P.) eocenica* and *P. terebraeformis,* which make the proposed development more plausible. The Reklaw species has an anal notch on the upper part of the whorl, which suggests that the genus belongs in the Turridae rather than the Buccinidae. It might be argued that the notch is of a similar character to that seen in *Surculites* Conrad, 1865d, a genus which Wrigley (1939) removed from the Turridae and placed in the neighborhood of the Fusinidae and Buccinidae. Wrigley's argument centered on the fact that the so-called notch on *Surculites* is dependent on the size of the carina, essentially straight on the early whorls, and increasingly sinuous on later ones. This is not the case in *P. (P.) eocenica* and to a lesser extent in the undescribed Weches species; in these species an anal notch is observed immediately after the protoconch. The protoconch too, is more typical of some Turridae, with the early, smooth whorls and the later, ribbed ones, rather than of a Buccinid family member. Several genera such as *Microsurcula* Casey, 1904 and *Lyrosurcula* Casey, 1904, have a very similar protoconch, and in the case of *Microsurcula* a similar apical sculpture too. Harris (1937) places *Microsurcula* as a subgenus of *Raphitoma* Bellardi, 1847, but following Powell (1966), it probably deserves full generic rank in the Turriculinae. In conclusion, the U-shaped sinus on the shoulder slope, type of protoconch and general similarity of the spire to *Microsurcula,* justify the transference of *Pyramimitra* to the Turriculinae. Even though *P. terebraeformis* and the closely related *Pyramimitra quadralirata* Dockery, 1977, do not show a definite turrid notch, the close taxonomic relationship to *P. (P.) eocenica* and short time interval between the species also justifies their transference to the Turriculinae. Powell (1966, pl. 7) illustrates several genera showing similarities to *Pyramimitra,* of which *Turridrupa* Hedley, 1922 appears particularly close.

Etymology.—The name *eocenica* notes the first reported occurrence of *Petrafixia* in the Eocene.

Type information.—Holotype: PRI 30464; paratype: PRI 30465. Type locality: locality 20.

Material examined.—Five specimens, the largest (broken) 3.1 mm in length.

Genus **PLEUROFUSIA** de Gregorio, 1890, p. 34

Type species.—Pleurotoma longirostropis de Gregorio, 1890, by original designation. Middle Eocene, Gosport Sand Formation of Alabama.

Diagnosis.—Shell moderate to fairly large in size; protoconch paucispiral, smooth, last quarter turn with arcuate riblets; spire high; sculpture of coarse ribs overriden by strong spiral cords; sinus broad, shallow, with the apex closer to the periphery than the suture; anterior canal long and unnotched.

Remarks.—This genus is restricted to the Eocene and Oligocene of Europe, and North and South America.

Pleurofusia? **huppertzi** (Harris, 1895a)
Plate 20, figures 21–22

Pleurofusia huppertzi Harris, 1895a, p. 58, pl. 4, fig. 9.

Turricula (Pleurofusia?) huppertzi (Harris). Harris, 1937, p. 52, pl. 10, fig. 9.

Pleurofusia? huppertzi (Harris). Palmer and Brann, 1966, p. 829; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, p. 24.

Original description.—"Size and general form as indicated in the figure; whorls 11, one and two smooth, three to ten somewhat inflated submedially, longitudinally costae obtuse, most prominent submedially, almost vanishing on the subsutural portions of the whorls, becoming short and nodular on the upper whorls, prominently spirally striate, the striae often irregular and waving on the medial portions of the whorls; body whorl costate and spirally striate, striae becoming of alternate strength on the beak." (Harris, 1895a, p. 58)

Remarks.—The Reklaw specimens are more elongate and the nodular costation is less prominent on the later whorls than in *P. huppertzi* s.s., otherwise the specimens are very similar. The protoconch however, is not typical of *Pleurofusia,* in which it is described as blunt, paucispiral and smooth except for a few axial riblets on the last one-quarter turn. The present specimens have a conical protoconch of four turns, the nucleus minute and blunt, the first three smooth and rounded-carinate below the middle, and the last turn with axial riblets and a subsutural line that slowly increases in strength. The Reklaw species of *P. huppertzi* could be the immediate ancestor of *Pleurofusia claibarena* Harris, 1937 from the Gosport Sand Formation of Alabama; this latter species has a similar profile and the same number of nodulations per whorl. One specimen with a worn apex has much more subdued ornamentation, particularly so on the shoulder slope and is very much closer to the type; no intermediate forms have been discovered yet. The species ranges from the Reklaw to the Weches Formation, Middle Eocene of Texas.

Type information.—Holotype: TBEG 35618. Type locality: locality 8. Figured Reklaw specimen: PRI 30505.

Material examined.—350+ specimens, the largest (incomplete): 38 mm length, 9.9 mm width.

Genus **LEPTOSURCULA** Casey, 1904, p. 57

Type species.—*Pleurotoma beadata* Harris, 1895a, by monotypy. Middle Eocene, Weches Formation of Texas.

Original description.—"In this genus the form is very slender, fusiform, the canal very long, the aperture and canal together being about half as long as the entire shell. The embryo is relatively very large, higher than wide, conical and composed of five or six polished whorls, the lower whorls gradually acquiring close-set longitudinal riblets, and then equally gradually the spiral lyrae. The type is the very isolated *P. beadata* Harris, of the Texas Eocene, a slender and much elongated species, with a long slender and tapering beak. The series of small rounded close-set nodules forming the subsutural collar, are completely independent of the relatively large and oblique costae, which are less than half as numerous. the strong even lyrae are a particular feature." (Casey, 1904, p. 57)

Remarks.—To date this genus is only known from the type. It ranges from the Weches Formation to the Cook Mountain Formation of Texas.

Leptosurcula carinata, new species

Plate 20, figure 23

Description.—Shell small, protoconch of about four smooth, submedially carinated whorls, axially ribbed and spirally striate. Adult whorls medially carinated, with a duplex, beaded, raised subsutural line, and a concave shoulder with fine spiral lines and costate below, the costae overriden by coarser lines. Retral sinus an asymmetrical U with the apex closer to the periphery than the carina. Body whorl less costate than the preceding and ornamented with regular spiral lines which decrease slowly in strength towards the base. Canal long and strongly twisted.

Remarks.—One broken specimen was obtained, split longitudinally but showing sufficient characters for description. This is only the second species to be assigned to *Leptosurcula.* The broad U-shaped sinus occupying most of the shoulder slope indicates that the ancestor of the genus is perhaps to be found within the Turriculinae, perhaps near *Turricula* Schumacher, 1817. Harris (1937) placed the genus in the family Raphitomidae, subfamily Clavinae, so the discovery of this new species supports Powell's placement of *Leptosurcula* in the Turriculinae. The carinate whorls, weak shoulder ornamentation and smaller and more conical protoconch will distinguish the Reklaw species from the type, *L. beadata.*

Etymology.—Noting the prominently carinated whorls which differ from the type.

Type information.—Holotype: PRI 30466. Type locality: locality 4.

Material examined.—One specimen, 6.7 mm length.

Genus **EOSURCULA** Casey, 1904, p. 145

Type species.—*Pleurotoma moorei* Gabb, 1860, by subsequent designation (Vokes, 1939, p. 118). Middle Eocene, Weches and Cook Mountain formations of Texas.

Original diagnosis.—"The embryo in *Eosurcula* is much narrower than in *Protosurcula,* strongly elevated and smooth throughout, the subsutural collar smaller and less developed, the fasciolar surface thence obliquely ascending but straight in profile or nearly so to the obtusely angulate periphery, on and below which the spirals become coarser. The aperture and canal nearly as in *Protosurcula*. . . ." (Casey, 1904, p. 145)

Remarks.—The genus is known from the Gulf Coast Eocene and doubtfully also the California Eocene.

Eosurcula moorei reklawensis, new subspecies

Plate 20, figures 18–20

Description.—Shell large, elongate, fusiform in shape. Whorls nine to ten, protoconch high, of three and one-half smooth whorls, apex flattened and the nucleus minute. Adult whorls carinate, with numerous spiral lines, stronger on the subsutural collar and carina, weaker on the concave shoulder, alternating in size below the carina and on the body whorl. Excepting the shoulder area, the spiral lines are crossed by numerous close-set longitudinal lines. Small beads occur at the intersections of the spiral and longitudinal lines. Length of aperture and canal together half the length of the shell.

Remarks.—This subspecies is the most elongate of all the *E. moorei* group and is further distinguished by the absence of apical tubercles and the presence of beaded surface ornamentation.

Etymology.—The specific name notes the Reklaw Formation where the species is found.

Type information.—Holotype: PRI 30470; paratypes: PRI 30471, 30472. Type locality: locality 20.

Material examined.—150 + specimens, the largest complete: 19 mm length, 5 mm width. Broken specimens indicate an original size to 40 mm length.

Genus **TROPISURCULA** Casey, 1904, p. 153

Type species.—*Pleurotoma (Drillia) caseyi* (Aldrich, 1903b), by subsequent designation (Harris, 1937, p. 57). Red Bluff Oligocene of Mississippi.

Original diagnosis.—"The shell in this genus is small in size, of slender form, with moderately elongate and slender beak and narrow, closely-coiled, multispiral embryo, which is higher than wide, and perfectly smooth and polished throughout. The ribs are about equal in number to those of *Pleurofusia* but culminate in transverse prominences at the summit of an angulate median periphery, and sometimes become gradually feebler on the larger whorls. The spiral lines are subequal amongst themselves, relatively rather coarse but low, and very close-set throughout." (Casey, 1904, p. 153)

Remarks.—The genus is often confused with *Surculoma* Casey, 1904, and indeed the adult sculpture of many of the Tertiary Gulf coast species is remarkably similar. The blunt, mammilate apex and paucispiral protoconch of *Surculoma* (most species now separated out under *Volutapex* (Harris), can distinguish species of that genus from *Tropisurcula.* The genus is known from the Eocene of the northern hemisphere.

Subgenus **TROPISURCULA** s.s.

Tropisurcula (Tropisurcula) milamensis, new species

Plate 21, figures 1–2

Description.—Shell small, fusiform, with short beak. Whorls 10 to 11, protoconch bluntly conical, of three to three and one-quarter smooth, polished whorls. Adult whorls with five or six oblique, nodose ribs, obsolete below the collar. Subsutural collar large, rounded, and wavy due to the prominent development of the ribs on the previous whorls. Surface with spiral lines, one medial line causing the whorls to be acutely carinated, another weaker one above the carination and a third above the lower suture. Fasciolar surface with fine striae. On later whorls, intermediate lines develop, becoming subequal in size particularly so below the carina. Body whorl with ribs absent at the initiation of the beak where the lines are stronger again. Sinus a broad open V, occupying the entire fasciolar surface. Aperture long, rounded, trapezoidal, outer lip thin and lirate within. Columella smooth, oblique and reflected. Aperture and canal two-fifths the length of the shell.

Remarks.—This species is closest to *Tropisurcula planus* n. sp. but has a shorter aperture and canal, and coarser ornamentation. The closest described species is *Tropisurcula caseyi* (Aldrich, 1903b) from the Red Bluff Oligocene of Mississippi. The Reklaw specimens are more elongate, have finer lines on the shoulder and coarser ones below, no well-defined keel, and stronger, more widely-spaced costae.

Etymology.—The specific name refers to the first discovery in Milam County, Texas.

Type information.—Holotype: PRI 30478; paratypes: PRI 30479–30482. Type locality: locality 20.

Material examined.—400+ specimens, the largest 10.0 mm length, 3.0 mm width.

Subgenus **EODRILLIA** Casey, 1904, p. 159

Type species.—Pleurotoma depygis Conrad, 1833b, by subsequent designation (Cossmann, 1906, p. 223). Eocene, Gosport Sand Formation of Alabama.

Diagnosis.—Shell smooth or finely spirally striate; protoconch conical, smooth, of three to three and one-half whorls; ribs well developed and not crossing the fasciolar surface; sinus broadly U-shaped, the center near the middle of the fasciolar surface; subsutural collar prominent; aperture short, canal very short.

Remarks.—Powell (1966, p. 45) places *Eodrillia* in synonymy of *Eopleurotoma* Cossmann, 1899, but the multispiral protoconch, strong subsutural collar and prominent rounded nodules separate that taxon well. Palmer and Brann (1966, p. 645) consider Cossmann's selection of *Pleurotoma depygis* as the type unfortunate, as a unique specimen of *P. depygis* still needs to be selected from the type lot of about 20 specimens. Harris (1937, p. 37), believed both the types of *P. depygis* and *Pleurotoma nuperus* Conrad, 1833b were contained in that type lot, which he noted represents the larger part of the Conrad *Eopleurotoma* collection. It appears that *P. depygis* as figured in Harris (1937, pl. 6, figs. 18–19, pl. 7, figs. 1–2) does represent a *Eopleurotoma* species with its long narrow flexuous ribs, and the apex of the V-shaped anal sinus just above the peripheral nodules. The problem is that Casey (1904, pp. 159–160) included *P. depygis,* which he synonymized with *Drillia laevis* Conrad, 1865a. This latter species is a *nomen nudum* as it only appears in Casey's list of species; other typical species mentioned by Casey include *Pleurotoma texana* Conrad, 1865a, and *Pleurotoma lonsdali* I. Lea, 1833, both now included in *Eodrillia* by Palmer and Brann (1966). The remainder of Casey's species are turrids figured by de Gregorio and since lost, although from the figures they also appear to be in *Eodrillia.* Moore (1962, p. 68) reported the type of *D. laevis* missing. Amongst Katherine Palmer's personal papers, however, is a photograph of *D. laevis* with the word "type" written on it; this photograph shows a specimen which appears to be identical to *P. lonsdali.* (These papers are now in the archives of The Paleontological Research Institution, Ithaca, NY.) It seems fairly clear that Conrad himself regarded *P. depygis* as a drillid as he includes *P. lonsdali* in synonymy. The best conclusion is that *P. depygis* is an *Eodrillia* as listed by Palmer and Brann (1966, p. 645), but that the figures and specimens shown by Harris are not Conrad's *P. depygis.* Genus

Eodrillia seems hardly deserving of full generic rank, as the same type of protoconch, nodular ribs and anal sinus are also seen in *Tropisurcula.* If forms like *Eodrillia texanopsis* (Harris, 1895a), with the long beak and canal, are also accepted as belonging to this taxon then the break between them and smoother forms of *Tropisurcula planus* is negligible indeed.

Tropisurcula (Eodrillia) planus, new species
Plate 21, figures 3–4

Description.—Shell small, fusiform with conical spire. Whorls nine and one-half; protoconch bluntly conical, of three and one-half to four smooth whorls. Adult whorls with six or seven rounded, oblique, nodose ribs, obsolete on the concave fasciolar surface. Suture wavy due to the prominent development of the ribs on the shoulder; subsutural collar thickened, sometimes duplex. Surface with numerous revolving lines, finer and more closely set on the fasciolar surface, larger and more widely spaced below. A feeble carina is formed with the first of the larger spiral lines positioned just above the whorls' maximum diameter. On the body whorl the most prominent line ends at the initiation of the canal, the other lines being more closely set towards the anterior end. Sinus broadly V-shaped, occupying most of the shoulder area. Aperture elongate-oval, outer lip thin and smooth within. Columella smooth and bent to the left. Aperture and canal together make up half the length of the shell.

Remarks.—This species is close to *Tropisurcula (Eodrillia) texanopsis* (Harris, 1895a), but may be distinguished by the shorter apex, the lack of polished whorls, the slight medial carination and multispiral, blunt protoconch. *T. (E.) planus* can be separated from other *Tropisurcula* species by its more elongate form, almost obsolete carination, and generally more subdued ornamentation.

Etymology.—The specific name *planus* (Latin, flat), refers to the smooth, flat shoulder.

Type information.—Holotype: PRI 30473; paratypes: PRI 30474–30477. Type locality: locality 20.

Material examined.—350+ species, the largest 15.0 mm length, 5.0 mm width.

Tropisurcula (Eodrillia) grandis, new species
Plate 21, figures 5–6

Description.—Shell broadly fusiform. Whorls nine and one-half; protoconch conical of three and one-half to four smooth whorls. Whorls with seven or eight prominent, rounded, nodular costae; a concave subsutural collar made wavy due to the costae on the previous whorl, and fine spiral lines almost obsolete on the collar. The lines are a little stronger and more widely spaced on the lower half of the whorls, strong on the beak. Anal sinus a broad V with the rounded apex in the center of the fasciolar slope. Aperture elongate, columella long, smooth, bent weakly to the left.

Remarks.—This Reklaw species resembles *Tropisurcula (Eodrillia) planus* n.sp. more closely than any other, and is distinguished from that species by its larger spiral angle, greater size and the strongly wavy subsutural collar formed by the strong costae. *T. (E.) grandis* lacks the short aperture and beak, and strong polish of *Tropisurcula (Eodrillia) texana* (Conrad, 1865a) from the Cook Mountain Formation, and the other previously described *Eodrillia* species. Several specimens do show a slight polish on the whorls.

Etymology.—Referring to the relatively large size of this species.

Type information.—Holotype: PRI 30478; paratype: PRI 30553. Type locality: locality 4.

Material examined.—Nine specimens, the largest: 16.9 mm long, 3.8 mm greatest diameter.

Genus **PROTOSURCULA** Casey, 1904, p. 144

Type species.—*Surcula gabbi* Conrad, 1865a, by original designation. Middle Eocene of Texas.

Original diagnosis.—"In this genus and *Eosurcula* there is no trace of ribbing, and the moderately large species comprising them may be considered allied more closely to the Cochlespira group than any other; the embryo in both is conical or conoidal and multispiral, and, in *Protosurcula* this is generally very large and with conspicuous longitudinal riblets on the lower whorls. The collar below the suture is cariniform and the long fasciolar surface between it and the obtuse periphery is broadly concave and with fine spiral lines; below the periphery the spiral lyrae are rather coarse. The columella is straight and generally simple, though sometimes having strong plicae above the middle. The spire tapers evenly to the apex and the beak is slender and frequently very long, the aperture and the long canal combined being much larger than the remainder of the shell in *gabbi* which is assumed to be the type." (Casey, 1904, p. 144)

Remarks.—*Protosurcula* to date is known from the Claiborne of the Gulf Coast and Northern Mexico.

Protosurcula? aurora, new species
Plate 21, figures 7–8

Description.—Shell large, fusiform. Whorls 12; protoconch bluntly conical, of four and three-quarters to five whorls, nucleus inflated and partially immersed, first one-half whorl deviated, the first three and one-half whorls smooth, shining and carinated below the middle, the succeeding whorls slowly developing widely spaced arcuate riblets and numerous spiral lines. The spiral lines continue and become part of the adult ornamentation whereas the riblets abruptly cease above the medial carination, the lower part continuing as a slowly vanishing crenulated keel. Adult whorls with a rounded carina that migrates from a submedial to a medial position and a collar that becomes progressively more crenulate. Surface covered with numerous spiral lines, larger on the collar and on the central carination. Body whorl coarsely spirally striate and with finer intermediate lines. Aperture ovate, columella long and straight.

Remarks.—This species is obviously directly in the phylogenetic line of *Protosurcula tenuirostris* Casey, 1904 from the Weches Formation, and *Protosurcula gabbi* (Conrad, 1865a) from the Cook Mountain and Laredo formations. The adult shell profile has stayed fairly constant throughout the development of the genus whereas the protoconch has changed radically. In *P.? aurora* the anterior part of the protoconch resembles the later adult sculpture and no demarcation is discernible. The Weches species *P. tenuirostris* is higher and lacks the spiral striation of the Reklaw species. Well-preserved specimens of *P. gabbi* sometimes show a multispiral highly conical protoconch topped by three to four whorls forming a minute vertical pillar. Specimens labelled "*P. gabbi*" from St. Maurice, Louisiana and from the Lewis House, 5.3 km east of Alto, Cherokee County, Texas, all in the Academy of Natural Sciences, Philadelphia, show some of the ribbing continuing on to the later whorls and having a more crenulated collar; these specimens appear to be in an intermediate stage of development between *P.? aurora* and *P. gabbi.*

Etymology.—The specific name *aurora* (Latin, dawn), notes the first known occurrence of the *Protosurcula* stock.

Type information.—Holotype: PRI 30483; paratypes: PRI 30484–30487. Type locality: locality 20.

Material examined.—200+ specimens, the largest complete one: 34 mm length, 9.5 mm width. One broken specimen measures 13.5 mm width.

Subfamily **TURRINAE** Swainson, 1840, p. 154[16]

Genus **CORONIA** de Gregorio, 1890, p. 23

Type species.—Pleurotoma acutirostra (Conrad, 1834) (= *Pleurotoma childreni* I. Lea, 1833), by subsequent designation (Palmer and Brann, 1966, p. 607). Eocene, Gosport Sand Formation of Alabama.

Original diagnosis.—"Testa turriculata; anfractibus angularis, carina granulosa vel crenulata, ornatis, saepe etiam aliis duabis costis spiralibus, cariniformibus, laeigatis (ex quibus antica inter carinam et suturam anticam, postica inter carinam et suturam posticam sita est) praeditis; rima potius profunda, angulosa vel subangulosa in carina vel in ejus proximitata incisa." (de Gregorio, 1890, p. 23)

Translation.—Shell turriculate, whorls angular, spiral sculpture strongest near the carina; carina crenulate or nodular, often defined with a duplex crenulated spiral line; sinus broad and not too deep, situated on the carina; sutures deeply impressed.

Remarks.—The genus is known from the Eocene of the Gulf Coast.

Coronia taylori, new species
Plate 19, figures 17–19

Description.—Shell small, whorls 10 to 11, protoconch high, of three and one-half to three and three-quarters whorls, the first one and one-half smooth, the remainder with fine riblets that are initially arcuate and becoming progressively more acute and finally protractive. Nucleus minute and partially immersed. Spire whorls submedially carinated, defined by an elevated band of regular squarish nodules. Suture deeply impressed, margined below with a strong cord; below that a concavity that initially contains one spiral line, with increasing age to up to nine or 10. Below the concavity is a keel, below that two strong lines, the lower one margining the suture. Body whorl with strong subequal spiral lines that decrease in size below the middle. Aperture elongate-oval, with a gutter and long, straight canal bent slightly to the left.

Remarks.—This appears to be the ancestor of *Coronia genitiva* Casey, 1904 from the Weches and Cook Mountain formations in Texas, to which it bears a close resemblance. The specimens can be separated into two groups on the type of protoconch, which in one group is slightly higher and has more widely spaced riblets than the other. The difference however, is not considered significant enough even for subspecific rank and may indicate sexual dimorphism in the species. A few specimens show the peripheral keel tending towards a duplex character, as in *Coronia childreni* (I. Lea, 1833). The *Coronia* group, comprising *C. childreni, Coronia margaritosa* (Casey, 1904) and *C. genitiva,* seems over-differentiated, the primary feature of all being the strong keel, which has one strong line above it and two below. The Reklaw species can be separated from the above-mentioned group of three by the combination of the nodules on the spire which occur conspicuously below the middle of the whorl, the stronger carina and spiral lines, and the smaller protoconch.

Etymology.—The specific name refers to Joe Taylor Creek where the species is abundant.

Type information.—Holotype: PRI 30561; paratypes: PRI 30562–30566. Type locality: locality 20.

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[16] = Pleurotominae Swainson, cf. McLean, 1971.

Material examined.—250+ specimens, the largest 21 mm in length, 5.0 mm width.

Coronia cf. **margaritosa** (Casey, 1904)
Plate 20, figures 10–11

Gemmula margaritosa Casey, 1904, p. 135; Harris, 1937, p. 16, pl. 2, fig. 14, 15, 17, figs. 16, 8
?*Coronia margaritosa* (Casey). Gardner, 1945, p. 240, pl. 27, fig. 7
Coronia margaritosa (Casey). Dockery, 1980, p. 126, pl. 41, fig. 7

Original description.—"Whorls with two rather widely spaced separated carinae below the suture, embryo relatively small in size, somewhat higher than wide, with three smooth spiral whorls, gradually increasing as usual, and two whorls covered with coarse and rather widely spaced riblets; peripheral duplex carina not strongly elevated, the space between it and the lower and larger of the subsutural carinae about twice as wide as the peripheral band and having two spiral threads and sometimes three other smaller ones in addition; space below the periphery with several spiral carinules; shell rather large, the beak straight but somewhat feebly, obliquely swollen towards tip; length of the aperture and canal together nearly two-fifths the length of the shell. Length of a specimen having nine body whorls 27 mm; width 7.8 mm Lower Claiborne Eocene of Smithville, Texas " (Casey, 1904, p. 135)

Remarks.—Only one specimen was obtained of this species. It is most closely allied to *C. margaritosa* but also shows affinities with *Coronia genitiva* (Casey, 1904). Juvenile specimens of *C. margaritosa* from the type locality at Smithville are very similar, but with increasing age the duplex subsutural carina becomes larger than the crenulated medial carina, giving a wholly different aspect to the shell. This specimen is close to that figured by Harris (1937, pl. 2, no. 14), a species from the lower Claiborne of Hickory, Mississippi. The species is reported from the Weches, Cook Mountain and Laredo formations in Texas, Mississippi and Mexico.

Type information.—Holotype: USNM 494348. Type locality: Smithville, Bastrop County, Texas. Figured Reklaw specimen: PRI 33186, from locality 4.

Material examined.—One specimen, 9 mm in length.

Genus **HESPERITURRIS** Gardner, 1945, p. 237

Type species.—*Turris nodocarinatus* Gabb, 1860, by monotypy. Claibornian Eocene of Texas.

Original diagnosis.—"Shell rather small or of moderate dimensions, slender, multispiral, the body rather abruptly constricted into the short anterior canal. Protoconch of genotype of five to five and one-half whorls, the initial turn minute and largely immersed, the three to three and one-half succeeding whorls smooth, shining, broadly rounded, and increasing rather rapidly in diameter, the final whorl in whole or part axially costate, the costae feebly arcuate. Sculpture elaborate, entire conch spirally lirate; peripheral and sutural collar noded, the peripheral nodes protractive, commonly confined to the peripheral area and obsolete towards the aperture. Posterior fasciole moderately wide, depressed. Sinus broadly U-shaped, moderately deep, the axis running closer to the periphery than to the posterior suture." (Gardner, 1945, p. 237)

Remarks.—To date five species or subspecies of this Eocene genus have been recognized, two of them restricted so far to Mexico.

Hesperiturris nodocarinatus crassus,
new subspecies
Plate 20, figures 1–3

Description.—Shell narrow, fusiform; protoconch bluntly conical, of three and one-half to four whorls, initially smooth, the last one-half to three-quarters whorl with widely spaced arcuate riblets. Nucleus moderately swollen and partially immersed. Adult whorls carinate below the middle and with a moderately swollen subsutural collar. Surface ornamentation of about 20 small collabral folds, most prominent on the carina, slightly less so on the collar and obsolete below the carina. The entire surface covered with spiral lines which increase in strength as they approach the lower suture. Body whorl with strong spiral lines increasing in strength on the beak. Sinus moderately deep (similar to *H. nodocarinatus* s.s.). Columella slightly oblique, canal long and bent to the left.

Remarks.—The difficulty of placing members of the *H. nodocarinatus* stock was commented on by Harris (1937, p. 34) and the assignment of these specimens to a subspecies of that is made primarily to emphasize its relationship to *Hesperiturris nodocarinatus* (Gabb, 1860), even though it may deserve full specific rank. The same wide variation of characters seen in *H. nodocarinatus* s.s. is also observed in the Reklaw specimens. The whorl profile ranges from almost flat to strongly carinate and the strength of the longitudinal folds ranges from strong to almost obsolete, particularly on the later whorls. The characters that are relatively constant and that can be used to differentiate the subspecies are the smaller swollen protoconch, the stronger spiral lines and the longitudinal folds, which persist between the medial carina and the subsutural collar. *Hesperiturris nodocarinatus enstrictus* (Harris, 1895a) from the Weches Formation has characters intermediate between the Reklaw Formation and Cook Mountain Formation species. A probable ancestor is *Eopleurotoma cainei* (Harris, 1899) from the Sabinian stage, this species has the ribs more constant in strength, more evenly rounded whorls and stronger spiral lines.

Etymology.—The subspecific name *crassus* (Latin, coarse), notes the rougher ornamentation of this species.

Type information.—Holotype: PRI 30449; paratypes: PRI 30450–30453. Type locality: locality 20.

Material examined.—400+ specimens, the largest 21.5 mm length, 7.0 mm width.

Hesperiturris? **monilis**, new species

Plate 20, figures 12–13

Description.—Shell solid, very small. Whorls eight. Protoconch conical of about four whorls, initially smooth, the last one to one and one-quarter whorls with fine riblets; nucleus swollen and partially immersed. Sculpture consists of a submedial row of axially elongated beads (16 to 18 on the body whorl), a crenulated subsutural beaded line with each bead corresponding to a submedial one, and one, rarely two, fine lines between the two rows of crenulation. A further smaller line borders the lower suture. Body whorl with four prominent lines beneath the strongly beaded spiral, occasional fine intermediate lines occur. Sinus a broad U, the center near the top of the submedial beads. Aperture elongate-oval with a prominent gutter; outer lip sharp, inside smooth, columella straight and smooth, callus deposit absent; canal twisted, moderate in size, bent and slightly emarginate, basally notched.

Remarks.—There seems to be nothing closely related to this species; superficially it might be taken to be a species of *Coronia.* The protoconch of *H.? monilis* with its widely spaced arcuate riblets and the broadly U-shaped sinus place it closer to *Hesperiturris* rather than *Coronia,* whose protoconch has numerous very fine riblets and a sinus which is a broad V with a rounded apex. The relationship of *H.? monilis* to *H. nodocarinatus* s.s. is also made clearer by an examination of *Hesperiturris nodocarinatus enstrictus* (Harris, 1895). This species from the Weches at Smithville has characters intermediate in development between *H.?monilis* and *H. carinatus* s.s. from the Cook Mountain Formation. Another more distantly related species, that has a similar development of axially elongated nodes, is *Hesperiturris amichel* Gardner, 1945, from the Laredo Formation of Mexico. There is no known descendant of *H.? monilis* in the later Claibornian, but the sculpture of *Coronia? nodulina bunkerensis* (Harris, 1937) suggests a relationship.

Etymology.—The name *monilis* (Latin, necklace), notes the similarity to a string of beads.

Type information.—Holotype: PRI 30454; paratypes: PRI 30455, 30456. Type locality: locality 4.

Material examined.—45 specimens, the largest 8.7 mm length.

Hesperiturris? **monilis levae**, new subspecies

Plate 20, figure 15

Description.—Shell solid, very small; whorls eight, spire strongly cyrtoconoid. Protoconch conical of about four whorls, initially smooth, the last one to one and one-quarter whorls with fine riblets; nucleus swollen and partially immersed. Sculpture consists of a submedial row of weakly arcuate beads (22–26 on the body whorl), a crenulated subsutural beaded line with each bead corresponding to a submedial one, and one, rarely two, fine lines between the two rows of crenulation. A further smaller line borders the lower suture. Body whorl with four lines beneath the beaded spiral, occasional fine intermediate lines occur. Sinus a broad U, the center near the top of the submedial beads. Aperture elongate-oval with a prominent gutter; outer lip sharp, inside smooth, columella straight and smooth, callus deposit absent; canal twisted, moderate in size, bent and slightly emarginate, basally strongly notched.

Remarks.—This species is distinguished from *monilis* s.s. by its highly cyrtoconoid spire, more subdued ornamentation and more prominent anterior notch.

Etymology.—The subspecific name *levae* (Latin, smooth) notes the smooth ornamentation.

Type information.—Holotype: PRI 30448. Type locality: locality 20.

Material examined.—Two specimens, the largest: 6.0 mm length, 2.2 mm width.

Subfamily **BORSONIINAE** Bellardi, 1875a, p. 20

Genus **BATHYTOMA** Harris and Burrows, 1891, p. 113

Type species.—Murex cataphractus Brocchi, 1814, by monotypy. Eocene and Oligocene of the Paris Basin, France.

Diagnosis.—Shell small, solid, biconical. Protoconch conical, of one and one-half to three and one-half whorls, the apex smooth and pointed; the last whorl with arcuate riblets. Adult sculpture of closely spaced, spiral cords overriden by axial growth lines causing the spirals to be beaded. Whorls usually with a beaded carina and concave shoulder. Outer lip thin-edged, sometimes lirate within; sinus a broad, open V with a narrow U at the apex which is on the peripheral carina. Columella usually with distinct, oblique, submedial fold, canal short and shallowly notched.

Remarks.—The genus is widely represented in the Eocene of the U.S., and it occurs today in deep water in the Caribbean. In Europe it persisted until the Pliocene. In India and the Far East it ranges from the Oligocene to Recent times. The Claibornian species referred to *Bathytoma* are very similar to *Glyptotoma* Casey, 1904; Harris (1937), regarded *Bathytoma* as a subgenus of the latter. *Glyptotoma* has a columella with a distinct ridge that splits into two or three strong folds, and also a strongly lirate outer lip.

Bathytoma cf. **nonplicata** Harris, 1937
Plate 20, figures 4–5

Bathytoma nonplicata Harris, 1937, p. 23, pl. 3, figs. 25, 25a; Brann and Kent, 1960, p. 118; Palmer and Brann, 1966, p. 525.

Original description.—"Form broad-turrited as figured; first embryonic whorl very minute, remaining three rapidly expanding and showing faint vertical ribbing below; subsutural band with pronounced beading, followed below by two to four crenulated spirals; peripheral duplex spiral pronounced, showing below one or two beaded spirals; body whorl anterior to the carination showing about fifteen beaded spirals, coarse at first but becoming finer and less beaded on the beak; lip within, with about eight rather fine but sharply defined spirals; columella entirely smooth." (Harris, 1937, p. 23)

Remarks.—The Reklaw species differs from *B. nonplicata* s.s. from the Cook Mountain Formation by the slightly weaker ornamentation, the gradual development of the ribbing on the protoconch, and a variable number of lirations within the outer lip; the number or lirations vary between zero and nine. The constant differences are considered great enough for separating the material. Gardner (1945, p. 248), regarded *Glyptotoma* as a subgenus of *Scobinella* Conrad, 1847, but the relationship seems closer to *Bathytoma,* as Powell (1966, p. 65) also noted. The relationship is also reinforced by observing that several of the Reklaw specimens show indications of three columellar folds under oblique lighting. The lack of lirations within the outer lip in the latter genus should not be used as a distinguishing character, as the discussion of Grant and Gale (1931, pp. 543–544) indicates.

Type information.—Holotype: PRI 2048a; paratype: PRI 2048b. Figured Reklaw specimen: PRI 30457, from locality 4.

Material examined.—40 Reklaw specimens, the largest: 8.5 mm length, 3.2 mm width.

Genus **DOMENGINELLA** Vokes, 1939, p. 121

Type species.—Turris claytonensis Gabb, 1864, p. 83, by original designation. Domengine Eocene, California.

Diagnosis.—Shell small, biconical, with moderately tall spire and gradually tapering body whorl ending in a short un-notched anterior canal. Adult sculpture with a prominent subsutural ridge, a concave shoulder with five beaded spirals and below that prominently beaded spiral cords. Outer lip lirate, columella smooth.

Remarks.—Vokes (1939) noted the great similarity of all features of this genus to *Scobinella* Conrad, 1847, except for the columella of *Domenginella,* which is smooth. Originally several species from the English Eocene were referred to this genus but modern authors have referred them elsewhere leaving *T. claytonensis* as the only species until now.

Domenginella ridgei, new species
Plate 20, figures 6–7

Description.—Shell moderate in size, solid, biconical. Whorls seven and three-quarters to eight, protoconch of four and one-half whorls, smooth and rounded except for the last whorl which is sculptured with widely spaced riblets. Adult sculpture of a smooth duplex subsutural collar, a concave sinus area with four spiral striae and obscurely crenate collabral growth threads. Below that, initially two and later three crenulated spirals, below that a narrowly excavated area. Body whorl and beak with up to 20 prominent beaded spirals, progressively weaker towards the base; interstitial weaker spirals sometimes present. Aperture quadrilateral, labrum with widely separated thin lirae, columella anteriorly marked by a low wide swelling, marking the beginning of a short canal. Two basal spirals continue into the aperture very indistinctly.

Remarks.—This is the first record of this West coast genus in the Gulf Coast Tertiary. A similar Gulf coast genus is *Moniliopsis* Conrad, 1865a, but that genus differs by the lack of plications on the labrum, a very narrow shoulder area, and lack of beaded ornamentation. The closest Claibornian species is the Reklaw clavid, *Bathytoma cf. nonplicata* n.sp.

Etymology.—Noting the occurrence in Ridge Creek.

Type information.—Holotype: PRI 30458; paratype: PRI 30459. Type locality: locality 4.

Material examined.—Three specimens, two juveniles and a large broken adult with only the last two whorls remaining.

Subfamily **CLAVINAE** Casey, 1904, p. 125

Genus **MICRODRILLIA** Casey, 1903, p. 276

Type species.—Pleurotoma cossmanni Meyer, 1887a, by subsequent designation (Cossmann, 1906, p. 223). Upper Eocene, Moodys Branch Formation of Mississippi.

Original diagnosis.—"They are all very small and characterized by a well-developed, multispiral, closely coiled embryo, having one to three of its basal whorls costulate, few body whorls which are wholly devoid of costae but spirally carinate, the rostral sinus relatively large, circularly rounded and close to the suture, the aperture oblique, columellar callus, with or without plications, and the canal short or obsolete." (Casey, 1903, p. 276)

Remarks.—The Paleogene *Microdrillia* species are unnecessarily split; intergrades certainly exist between many of the Texas Claibornian Eocene populations when large samples are considered. To correctly determine the relationships a revision of all the Paleogene species should be conducted with sufficient samples of each. That is outside the range of this report. It is possible four species of *Microdrillia* exist in the Reklaw deposits; two are assigned with some confidence near existing taxa. Given the range of variation seen in these two, and knowing the variation in the Cook Mountain and Stone City species, it would be pointless to define the other two without more material. The genus is widely distributed from the Eocene to Recent.

Microdrillia rostratula Casey, 1903
Plate 21, figures 12–13

Microdrillia rostratula Casey, 1903, p. 277; Aldrich, 1921, p. 7; Palmer and Brann, 1966, p. 770, pl. 5, figs. 7, 8.

Original description.—"Base of shell distinctly rostrate; body whorls about four in number. Form stout, the spire whorls short, about three times as wide as long, with a sub-duplex subsutural collar and three other single carinae, the fasciolar surface with two fine revolving threads; beak short and broad; lines of growth strongly marked; embryo well developed as usual higher than wide, ovulate at tip, with three smooth and two costate whorls. length 5.7 mm, width 2.3 mm Lignitic Eocene. Wood's Bluff Horizon." (Casey, 1903, p. 277)

Remarks.—This Reklaw species is very similar to *M. rostratula* from the Sabinian Eocene. The two fine revolving threads on the fasciolar surface are a little lower, the intermediate, spiral lirae on the body whorl are weak to absent, and the protoconch riblets are finer than in the Wood's Bluff species, but the differences are not considered significant enough even for subspecific rank.

Type information.—Lectotype: USNM 481550. Type locality: Choctaw Corner, Clarke County, Alabama. Range: lower Eocene, Bashi Member (type), Sabine stage, Alabama; Reklaw Formation, Texas. Figured Reklaw specimen: PRI 30567, from locality 20.

Material examined.—48 specimens, the largest: 6.6 mm length, 2.7 mm width.

Microdrillia aff. **robustula** Casey, 1903
Plate 21, figures 14–15

Microdrillia robustula Casey, 1903, p. 277; Harris, 1937, p. 93, p. 14, figs. 38, 39, 48, 48a; Brann and Kent, 1960, p. 554, Palmer and Brann, 1966, p. 769. (Not p. 555, No. 2615c= *M. infans* (Meyer) ? var. Harris.)

Original description.—"Embryo as wide as high, obtusely oval at tip, with three smooth and two costulate whorls; subsequent whorls four in number, each with one subsutural and three other equal carinae; fasciolar surface without a revolving thread. Length 5.6 mm, width 2.25 mm. Lower Claiborne Eocene, St. Maurice La." (Casey, 1903, p. 277)

Remarks.—The Reklaw specimens can be separated into two groups, the first shorter with one and one-quarter to one and a half whorls of the final protoconch whorls ribbed, and the second group with a full two final protoconch whorls ribbed and quite elongate. Both groups have somewhat stronger spiral sculpture than *M. robustula* s.s. and have the lowest of the three lirae just above the lower suture. Several Reklaw specimens show one or more fasciolar threads, all other characters being similar. In my experience a large enough sample of any particular *Microdrillia* species always includes some specimens displaying this feature, so it is not considered to be of specific importance.

Type information.—Syntype: USNM 481559. Figured Reklaw specimen: PRI 33110, from locality 20.

Material examined.—14 specimens, the largest: 6.5 mm long.

Microdrillia sp.
Plate 21, figures 20–21

Remarks.—One of the remaining species, quite different from the two preceding described species, is figured here. Protoconch with three and one-half smooth whorls and one finely costulate one. Primary spire sculpture is dominated by two lines, a subsutural one and a slightly stronger submedial line. The form is rather similar to *Microdrillia harrisi* (Aldrich, 1895a) from the Cook Mountain Formation, but it lacks the columellar plaits and labial lirae.

Material examined.—Two specimens, from locality 4. Figured specimen: PRI 30568, 6.8 mm length.

Genus **SPIROTROPIS** Sars, 1878, p. 242

Type species.—Pleurotoma? carinatum Philippi, 1844a, by monotypy. Recent in Scandinavian seas.

Diagnosis.—Shell of moderate size, thin, fusiform, with strongly carinated whorls and a short, straight, un-notched anterior canal. Protoconch of about one and one-half to two smooth whorls ending in a sharp, medial carination. Adult sculpture initially with a few weak, peripheral nodes, then smooth and moderately to strongly carinate. Anal sinus U-shaped occupying most of the shoulder slope. Outer lip smooth within, thin and prominently swept forward. Columella narrow, smooth and bent, plicae absent, callus deposit thin.

Remarks.—According to Powell (1942), the distribution of this genus includes Scandinavia, the North Atlantic, Mediterranean and Canary Islands, mostly in deep water. The genus also occurs in the Miocene to Pleistocene in Europe and the Eocene of the West Coast of North America where it is represented by two species: *Spirotropis (Antiplanes) cf. bulimoides* (Dall, 1919) and *Spirotropis (Antiplanes) perversa fernandoensis* (English, 1914).

Spirotropis claibornica, new species

Plate 21, figures 16–17

Description.—Shell very small, whorls seven and one-half. Protoconch of one smooth, inflated whorl followed by one-quarter whorl that is sharply medially carinated; nucleus inflated and flattened. Adult whorls with a rounded carina, initially in the medial position and becoming increasingly higher on later whorls. The first one-half whorl coarsely costate beneath the carina, otherwise smooth except for obsolescent, spiral lines and an almost imperceptible irregular, collabral thickening of the shell. Suture impressed, margined by an impressed line, anal sinus U-shaped with the base slightly nearer the periphery than the suture. Body whorl abruptly constricted to a short, straight neck. Aperture pyriform, outer lip smooth within, unfortunately broken, but growth lines show it to have been produced forward with the edge almost straight until the start of the neck where it swings back sharply. Columella smooth, bent to the right and moderately twisted. The parietal edge curves into the aperture anteriorly and then out again to meet the start of the outer lip.

Remarks.—This assignment is the first occurrence of this genus in the Gulf coast. The shoulder is higher than in other members of the genus, but the smooth whorls, large globose protoconch, initially costate whorl, shape of the sinus, and shape of the outer lip is the same as *Spirotropis* s.s. Three similar genera occurring in the Gulf coast are: *Orthosurcula* Casey, 1904, which has a similar keel but also a prominent collar and a conical multispiral protoconch; *Cochlespira* Casey, 1904, which is represented in the Claibornian by *Cochlespira engonata* Conrad, 1865a, has a similar protoconch, is much more sharply carinated, lacks all axial sculpture, has a notched canal and a narrow false umbilicus; subgenus *Volutapex* n. subgen., of *Surculoma* has a mammilate protoconch with the tip bulbous and asymmetrical, whorls submedially carinate over the entire conch and a different shaped anal sinus. Powell (1966) notes the presence of a columellar fold in *Volutapex* but this is an error. Within the known Claibornian genera *Spirotropis* appears to be near *Volutapex* which suggests a closer relationship than is indicated by their assignment to date in different subfamilies. Grant and Gale (1931, p. 547) have noted the relationship of *Spirotropis* to *Turricula* Schumacher, 1817, a genus to which Harris (1937) and Palmer and Brann (1966), assign *Surculoma* as a subgenus.

Etymology.—Noting the first occurrence of this genus in the Claibornian.

Type information.—Holotype: PRI 30488. Type location: locality 4.

Material examined.—1 specimen, 7 mm length, 2.6 mm width.

Subfamily **CLATHURELLINAE** H. and A. Adams, 1858, p. 654

Genus **EOCYTHARA**, new genus

Type species.—Eocythara texana, n. sp.

Generic Diagnosis.—Protoconch of about three and one-quarter whorls, the first one to one and one-quarter smooth, the remainder with fine protractive riblets. Adult sculpture of longitudinal rounded costae, spiral lines and a surface which is minutely imbricated or "frosted". Sinus moderately deep, V-shaped, weakly sinuous near the suture. Aperture long with two callus pads on the interior, marking each end of the sinus. Columella straight, smooth and angled to the left. Outer lip sharp, convex below the middle and with a weak stromboid notch. Basal notch not present or only obscurely so.

Remarks.—This genus is evidently the precursor of *Eoclathurella* Casey, 1904, and many of the Miocene clathurids of which *Pachycythara* Woodring, 1928, and *Pyrgocythara* Woodring, 1928, are representatives, are known from the Caribbean basin and Florida. The genus *Raphitoma* Bellardi, 1847, to which *Eocythara* bears a superficial resemblance, is thinner-shelled, has a shallow sinus and a long tapering canal. Most closely allied to *Eocythara* are the two similar genera *Adelocythara* Woodring, 1928, and *Pachycythara* Woodring, 1928. Both of these genera have smaller protoconchs of up to two and one-half whorls which show a few fine or obscure protractive riblets on the last one-quarter turn. The protoconch of *Eocythara*, in contrast, has the last two to two and one-quarter whorls more prominently sculptured, a much shorter canal, and a deep anal notch margined with strong callus build-up. An incipient stromboid notch is also seen in *Platycythara* Woodring, 1928, while the imbricate or "frosted" surface is a feature also common to *Pachycythara* and *Pyrgocythara*. Dockery (in MacNeil and Dockery, 1984, pp. 216–217) assigns four species to *Clathurella* Carpenter, 1857, from the Oligocene of Mississippi. This genus is lirate or denticulate on both the labrum and inner lip, has subcarinated whorls, possesses no stromboid notch, has the axial ribs conspicuously weaker on the fasciolar slope, and has a twisted siphonal canal. The type species of *Clathurella* is a solid shell, with a "frosted" or minutely pustulose surface, a condition not noted by Dockery in the Mississippi specimens. The earliest clathurellid known to date from the Gulf coast is *Eoclathurella* Casey, 1904 from the Upper Eocene of Louisiana. Species of this genus are very small, have axial and spiral sculpture of similar strength, but with weaker spirals present on the fasciolar area, and a plicate inner lip. Clathurellids are uncommon but cannot be called rare, numerous specimens having been collected by the author from both the Weches and Cook Mountain formations in Texas; most of them show characters intermediate between the Reklaw forms and the Upper Eocene and Oligocene forms.

Etymology.—The generic name *eo-* (Latin, early), *cythara* (Latin, harp), denotes a probable ancestor of many of the Neogene Cythara stock.

Eocythara texana, new species
Plate 21, figures 9–11

Description.—Shell small; protoconch as in the generic description, whorls about six and one-half. Adult whorls with 10 to 11 rounded sigmoid ribs and crisp spiral lines, three to four on the spire whorls and 15 or more on the body whorl. Basal lines more indistinct, the entire surface of the whorl secondarily covered with minute longitudinal and spiral striae, the intersections forming minute pustules. Aperture long, outer lip sharp and thickened within, sinus broadly V-shaped, occupying most of the shoulder area. Inner lip and columella straight with a few of the spiral lines crossing medially into the aperture. Canal weakly flaring below.

Remarks.—Nothing similar to this is known in the Paleogene of the New World; the frosted surface, smooth canal and labrum and large fasciolar surface free of spiral sculpture will distinguish this species from others. In the Miocene of Jamaica *Adelocythara primolevis* Woodring, 1928 is quite similar on the spire, although as noted above the aperture and canal of species in this genus are different.

Etymology.—The specific name notes the occurrence in Texas.

Type information.—Holotype: PRI 30489; paratypes: PRI 30490–30493. Type locality: locality 20.

Material examined.—140+ specimens, the largest: 6.6 mm length, 2.6 mm width.

Eocythara lineata, new species
Plate 21, figures 18–19

Description.—Shell very small, protoconch of three rounded whorls, rapidly expanding, densely sculptured with fine arcuate riblets, the tip enrolled. Adult whorls rounded with axial ribs and spiral lines, the lines weaker above the mid-section of the whorl, on the body whorl an intermediate stria may occur. Collabral growth lines densely regular and raised, more prominently on later whorls. Aperture narrow, outer lip thin-edged, thickened periodically by the ribs, columella straight or slightly excavate, canal short and slightly emarginate.

Remarks.—The species differs principally from *Eocythara texana* n. sp. in having spiral lines over the entire adult shell, a shorter form and weaker, imbricated, surface ornament, only developing on the second adult whorl. In many ways the species resembles *Raphitoma (Microsurcula) nucleola* Casey, 1904, from the Middle Eocene of Louisiana, the type species of *Microsurcula,* suggesting that the root stocks of *Eocythara* and *Microsurcula* are very close. Species belonging to subgenus *Microsurcula* are more elongate, have carinated whorls, a subsutural collar, a concave shoulder, and on the shoulder, ribs of reverse curvature from that on the body whorl. *R. (M.) nucleola* is atypical of most species assigned to *Microsurcula,* in its short, rounded form, but may still be separated on the basis of the above characters. Another similar species is *Eoclathurella obesula* Casey, 1904, from the Upper Eocene Jackson Group, which has the same type and strength of ribs and spiral lines; this species, however, lacks any trace of "frosting", is strongly lirate or denticulate within the aperture, and has a smaller protoconch that is widely ribbed on the final turn.

Etymology.—The specific name *lineata* (Latin, line), refers to the spiral lines covering the entire adult whorls.

Type information.—Holotype: PRI 30494; paratype: PRI 30495. Type locality: locality 20.

Material examined.—Six specimens, the largest 3.9 mm length.

Genus **VARICOBELA** Casey, 1904, p. 162

Type species.—Strombus smithii Aldrich, 1885, by original designation. Red Bluff Oligocene of Mississippi.

Revised description.—Shell of moderate size, thick and inflated, with regularly rounded whorls. Protoconch large, broadly conical, of three or four whorls, initially smooth, the last whorl with a reticulate pattern. Sculpture of narrow, obliquely sigmoid ribs, fine spiral lines, and occasional varices. Aperture half the length of the shell, oblique; canal short and narrow; inner lip smooth; labrum thickened and smooth.

Remarks.—Dockery (in MacNeil and Dockery, 1984, p. 198) assigns this genus to the Turriculine because of Casey's comparison of the protoconch to that of *Pseudotoma* and Powell's (1969, p. 382) synonymizing that latter genus with *Acamptogenotia* Rovereto, 1899. Powell (1969, p. 143) expresses doubt that the genus is a turrid and considers it better placed in the Buccinoidea. The genus appears to be restricted to the Eocene and Oligocene of the Gulf coast.

Varicobela filum, new species

Plate 21, figures 22–23

Description.—Shell small; whorls six; protoconch of three to three and one-half broadly conical whorls, initially smooth, the last half whorl with gradually developing reticulate sculpture that merges imperceptibly into the adult. Teleoconch whorls with 14 to 17 sigmoid ribs, becoming slightly weaker as they approach the deeply impressed sutures; terminal varix present with usually one or two more on previous whorls; sinus very broad, shallow, situated just below the suture, marginally stronger on earlier whorls. Spiral sculpture of regularly spaced thin lines and an intermediate weaker line between each pair; where the spirals cross the axials the sculpture is nodose; on the spire and above the point of greatest inflation on the body whorl the intermediate lines are centrally placed, on the lower portion of the body whorl the line migrates to a posterior position and on the beak to a central position again. Over-running the major sculpture are exceedingly fine and close-set collabral threads. Aperture elongate, labrum smooth, thickened into the interior beneath the terminal varix; prominent anal notch, margined on the labrum by a weak swelling; columella excavated; callus wash thin, showing some of the underlying spiral lines; canal straight; siphonal fasciole present but very weak.

Remarks.—Two species of *Varicobela* have been described previously, *Varicobela smithii* (Aldrich, 1885), and *Varicobela aldrichi* Dockery, 1984, both from the Oligocene of Mississippi. Both of these are larger, have a straight to coeleoconoidal spire rather than the cyrtoconoid shape of *V. filum,* and lack the close-set collabral threads of *V. filum.* Both macro- and micro-sculpture show much similarity with the two *Eocythara* species described previously and the apertural features are similar, excepting that *V. filum* lacks an anal notch. The lack of an anterior notch, weak sinus, and generally similar sculpture to the *Eocythara* species have caused the assignment here to the Turridae.

Etymology.—The name *filum* (Latin, thread), refers to the micro collabral sculpture.

Type information.—Holotype: PRI 30569; paratype: PRI 33074. Type locality: locality 4.

Material examined.—Six specimens, the largest complete (the holotype), 8.8 mm length.

Subfamily **DAPHNELLINAE** Casey, 1904, p. 126

Genus **RAPHITOMA** Bellardi, 1847, p. 538

Type species.—*Pleurotoma hystrix* Cristofori and Jan, 1832, by subsequent designation (Monterosato, 1875, p. 72). Pliocene of Italy.

Diagnosis.—"Shell of medium size, spire moderately high; whorls rounded, sculpture usually in both directions forming a reticulate pattern of raised lines; aperture varying from two-fifths to a half the length of the shell, ovate, outer lip slightly thickened, with at some growth stages a row of very fine denticulations on the inner lip, lip rounding back posteriorly to a moderately deep, usually not reinforced posterior notch close to the suture, inner lip not thickened, columella usually somewhat flexuous, anterior canal not wide, usually sharply defined but not very short, often notched behind." (Grant and Gale, 1931, p. 609)

Remarks.—Powell (1942, p. 125), who only recognizes *Raphitoma* from the Pliocene to Recent, gives a short discussion on the validity of type species *P. hystrix.* Wenz (1944, p. 1452), who also regards *Surcula* as a subgenus of *Raphitoma,* has it ranging from the Eocene to Recent; Davies (1971, p. 391) gives the Geologic range of *Raphitoma* as Paleocene to Recent. The two Reklaw species possess a multispiral protoconch similar in nature to *P. hystrix* rather than to the modern representative of that species, separated under the name *Raphitoma pseudohystrix* Sykes,1906, which has a paucispiral and globular protoconch.

Subgenus **MICROSURCULA** Casey, 1904, p. 154

Type species.—*Microsurcula nucleola* Casey, 1904, by original designation. Middle Eocene of Louisiana.

Original diagnosis.—"Shell very small, of juvenile aspect. Protoconch relatively large, conical, multispiral, closely-coiled and with about five whorls, initially smooth, the last one to three with fine arcuate longitudinal riblets. The periphery is more or less obtusely swollen, the ribs small and numerous, reduced in size and reversed in curvature on the broad fasciolar surface, generally attaining the suture or small subsutural collar above. The canal is rather tapering in form, straight, moderate in length, and together with the aperture about half as long as the shell." (Casey, 1904, p. 154)

Raphitoma (Microsurcula) georgei reklawensis, new subspecies

Plate 22, figures 1–2

Description.—This subspecies is more elongate than *R. (M.) georgei* s.s., has a subsutural collar, and an almost medial carination of the whorls. On the shoulder of the body whorl are spiral lines that alternate in size, and the protoconch is coarsely ribbed.

Remarks.—Raphitoma (Microsurcula) georgei (Harris, 1899) is from the Lower Eocene Hatchetigbee Formation of Alabama.

Etymology.—The subspecific name notes the occurrence in the Reklaw Formation.

Type information.—Holotype: PRI 30496; paratype: PRI 30497. Type locality: locality 20.

Material examined.—Four specimens, the largest: 3.9 mm length, 1.5 mm width.

Raphitoma (Microsurcula) bastropensis, new species

Plate 22, figures 3–4

Description.—Shell very small, solid. Protoconch of about three and one-half whorls, the last whorl with widely spaced riblets. Subsutural collar visible on protoconch and first adult whorl. Surface obscurely opalescent, ornament of 15 to 16 longitudinal ribs per whorl and numerous spiral lines. On the fasciolar surface the lines barely override the axials whereas on the carina and below they do so strongly, forming weak nodes at the intersections. Sinus a shallow U occupying all of the shoulder slope. Aperture quadrilateral, outer lip thin, smooth within. Columella straight, no discernible callus; canal short and slightly twisted.

Remarks.—This species differs from *Raphitoma (Microsurcula) iuventae* n.sp. in its squat form and about two to three more ribs per whorl. The probable descendant is *"Pleurotoma (Bela)" rebeccae* Harris 1895a from the Weches Formation, from which it differs in having a wider form, lack of a subsutural raised line, and wider and more even spiral lines. Harris (1895a, p. 64) originally places *"P. (B.)" rebeccae* under section *Bela* Gray, 1847b, first as a subgenus of *Pleurotoma* and later (Harris 1937, p. 79) as a subgenus of *Raphitoma.* Palmer and Brann (1966, p. 839) reinstate Harris's original placement. According to Powell (1966, p. 97–98), *Bela* has a small protoconch, initially smooth, the last whorl with spiral rows of tubercles; its teleoconch whorls have axial folds that do not cross the shoulder slope, and densely spirally striated whorls. The protoconch, overall whorl sculpture, and sinus make the present placement more likely.

Etymology.—Noting the occurrence in Bastrop County, Texas.

Type information.—Holotype: PRI 30498; paratype: PRI 30499. Type locality: locality 4.

Material examined.—Seven specimens, the largest 4 mm length.

Raphitoma (Microsurcula) iuventae, new species

Plate 22, figures 5–6

Description.—Shell small, fusiform. Whorls six to seven, protoconch bluntly conical of four rounded whorls, the first three smooth and the last with widely spaced, oblique riblets that increase in size and merge without break into the adult longitudinal folds. Adult whorls medially carinated, with an impressed suture which is margined below by a large, rounded line. Spiral lines cover the entire whorls and are a little stronger on the carina. Whorls with eight to nine oblique folds, obsolete on the collar and on the body whorl at the start of the canal. Sinus deeply U-shaped, occupying the entire shoulder slope. Aperture subovate, outer lip thin. Anterior canal long, oblique and slightly rostrate.

Remarks.—On some specimens only the upper portion of the shoulder is smooth and there are strong lines on the lower part, close to an as yet undescribed species from the Middle Claibornian in the Stone City Beds of Texas. The gradual change seen from juvenile to adult sculpture appears to be unique in the *Microsurcula* species, in outline the species otherwise resembles *Raphitoma (Microsurcula) intacta* (Casey, 1903) from the Oligocene of Mississippi; the protoconch and early whorls alone distinguish the two species. The sculpture is also similar to that of a juvenile *Surculoma* but the protoconch is different; in general the aspect is that of a juvenile shell but no larger ones, or even fragments have been found in the Reklaw.

Etymology.—The specific name *iuventae* (Latin, young), refers to the juvenile aspect of the shell.

Type information.—Holotype: PRI 30500; paratypes: PRI 30501–30504. Type locality: locality 20.

Material examined.—51 specimens, the largest: 6.0 mm width, 2.2 mm width.

Superfamily **ARCHITECTONICOIDEA**

Taylor and Sohl, 1962, p. 10

Family **MATHILDIDAE** Dall, 1889c, p. 144

Genus **GEGANIA** Jeffreys, 1884, p. 365

Type species.—Gegania pinguis Jeffreys, 1884, by monotypy. Recent from Cape Modego, Eastern Atlantic.

Diagnosis.—Shell small, coeleoconoidal, nucleus blunt, immersed and partially covered. Whorls bluntly carinate, with deeply impressed sutures; sculpture of spiral lines and fine oblique growth-lines. Body whorl larger than the remainder, base inflated. Aperture essentially circular, almost holostomatous, outer lip oblique, columella smooth, straight or feebly concave, inner lip callus partially covering the umbilicus.

Remarks.—The genus ranges from the Upper Cretaceous to Recent.

Gegania antiquata texana (Palmer, 1937)
Plate 10, figures 1–2

Tuba (Littorina) antiquata Conrad. Heilprin, 1891, p. 400
Tuba antiquata texana Palmer, 1937, p. 92, pl. 9, figs. 8,9; Brann and Kent, 1960, pp. 886–887.
Gegania texana (Palmer). Gardner, 1945, p. 150
Gegania antiquata texana (Palmer). Palmer and Brann (1966), p. 698.

Original diagnosis.—"Shell large, spire high for the species; whorls six; nucleus typical; sculpture of the post-nuclear whorls consists of four strong primary ribs, the first and fourth smaller than the two middle ribs; two, middle, spiral lines increasing in size making the whorls of the spire bicarinate; three to six, fine thread-like, spiral ribs occur between the primary ribs; all crossed by longitudinal threads which at the intersections form a node; below the strong bicarination of the body whorl nine to eleven, spiral ribs occur to the base; one or more, spiral threads alternate with the primary series." (Palmer, 1937, p. 92)

Remarks.—One small specimen was obtained which appears to be specifically identical to *Gegania antiquata texana* from the Weches Formation of Texas and Mexico. The only differences noted between this specimen and typical *texana* s.s are the more elongated form, finer revolving sculpture and a larger protoconch.

Type information.—Holotype: PRI 2473. Figured specimen: PRI 30550, from locality 4.

Material examined.—One specimen.

Genus **MATHILDA** Semper, 1865, p. 330

Type species.—Turbo quadricarinata Brocchi, 1814, by original designation. Tertiary of northern Italy.

Revised diagnosis.—Shell medium-sized, turrited, slender. Protoconch heterostrophic, not immersed. Sculpture of rounded whorls with strong spiral sculpture and axial threads. Base flat to arched, aperture ovate, entire, basal lip everted. Columella smooth, non-plicate.

Remarks.—The genus ranges from the Upper Cretaceous to Recent.

Mathilda (Mathilda) cf. **retisculpta aldrichi**
Palmer, 1937

Mathilda retisculpta aldrichi Palmer, 1937, p. 87, pl. 9, figs. 11, 14.

Original description.—"Shell medium in size, elongate; nucleus heterostrophic consisting of three whorls, first whorl minute, last whorl enlarged; post nuclear whorls coarsely ornamented with spiral lines and longitudinal ribs, which at their intersections form nodes. There are five spiral ribs on the whorls of the spire and ten spiral ribs on the body whorl. The longitudinal ribs become obscure at about the sixth spiral rib on the body whorl. The remaining spiral ribs on the body whorl are not nodose. The aperture is ovate." (Palmer, 1937, p. 87)

Remarks.—This specimen closely resembles *M. r. aldrichi*. In addition to the four nodose ribs of Palmer's subspecies, the Reklaw specimen has three very small ribs below the suture. On the body whorl of *M. r. aldrichi* the longitudinal ribs are nearly effaced by about the sixth spiral rib while in this species they remain visible and continue as fine threads. Were it not for its elevated mathildid nucleus, *Mathilda retisculpta* (Meyer and Aldrich, 1886) and the subspecies *M. retisculpta aldrichi* would be more readily placed in *Acrocoelum* Cossmann, 1888, which is also in the Mathildidae. A very similar species from the Paris Basin is *Acrocoelum bouryi* Cossmann, 1888.

Type information.—Holotype: PRI 2742; paratype: PRI 2741. Type locality: Orangeburg, South Carolina. Range: McBean Formation. Figured Reklaw specimen: PRI 33104, from locality 4.

Material Examined.—3 specimens, the largest complete: 7.1 mm length, 2.5 mm maximum diameter; one fragment with 4.8 mm maximum diameter.

Mathilda (Mathilda) cf. **claibornensis**
Aldrich, 1887
Plate 10, figure 17

Mathilda claibornensis Aldrich, 1887, p. 83; Palmer, 1937, p. 88, pl. 9, fig. 1 copy Aldrich.
Tuba (Mathilda) claibornensis Aldrich. Aldrich, 1895b, p. 15, pl. 1, fig. 7.

Original description.—"Shell very minute, embryonic whorls three, and placed as usual in the genus, the adult whorls (but three remaining in the type) with three rounded smooth ring-like bands, the intervening spaces having impressed longitudinal lines which do not pass over the bands. Locality: Claiborne Ferruginous Sand. Very rare, but the second species known from this famous deposit." (Aldrich, 1887, p. 83)

Remarks.—Two small fragments were obtained that are doubtfully referred to *M. (M.) claibornensis*. Apparently Palmer (1937, pl. 9, fig. 1) had only the one juvenile shell; the three strong ribs are diagnostic of this species however, and stay relatively constant in strength on succeeding whorls. The species is common at certain levels at the Stone City Member type locality and may reach lengths of 5 mm.

Figured Specimen.—PRI 30415, from locality 20.

Type information.—Holotype: USNM 638864. Type locality: Claiborne Bluff, Alabama River, Monroe County, Alabama.

Material examined.—Two broken specimens, the largest 4.1 mm in width, with only the body whorl and half the previous whorl remaining.

Subgenus **ECHINIMATHILDA** Sohl, 1960, p. 131

Type species.—Mathilda (Echinimathilda) corona Sohl, 1960, by original designation. Upper Cretaceous, Ripley and Owl Creek Formations of Mississippi.

Original diagnosis.—"Small- to medium-sized turriculate shells with a partially submerged and deviated protoconch; whorls shouldered; sides rounded; sculpture of nodose to spiny spiral lirae and ribbons; columella lip reflected." (Sohl, 1960, p. 131)

Remarks.—Prior to this report the subgenus was restricted to the Upper Cretaceous.

Mathilda (Echinimathilda?) cribraea, new species
Plate 10, figures 5–7

Description.—Protoconch one and three-quarter to two bulbous whorls, set at an angle of 45° from the shell axis, immersed to a level at the base of the nuclear whorl. Adult sculpture begins abruptly and consists of up to seven shouldered whorls, the shoulder becoming progressively more acute, later whorls with an angle approximating 90°, rounded below. Spire whorls with five to six spiral lines below the shoulder, crossed by numerous weaker longitudinal lines, the intersections of the two forming prominent nodes, body whorl with 10 or 11 spiral lines. On the base of the body whorl the spiral lines continue undiminished, while the longitudinal lines become fine threads. Aperture almost elliptical in shape, outer lip thin, columella lip thickened and slightly reflected.

Remarks.—Under the microscope the sculpture is seen to be a regular and finely cancellated pattern. The nearest Tertiary analogue to this species seems to be *Mathilda retisculpta* (Meyer and Aldrich, 1886) from the Cook Mountain Formation of Mississippi. I have also found the subgenus in the Upper Cretaceous Kemp Clay Formation in Texas. The protoconch in *M. (E.) cribraea* is not immersed to the same degree as the type species of the subgenus. As this is a primary character in the definition of the subgenus this Tertiary species is assigned here with some hesitation; in all other respects it is very close to the type species, *M. (E.) corona.* A few individuals do not show the shoulder carina becoming progressively more acute, but that feature by itself does not seem to warrant further taxonomic separation.

Type information.—Holotype: PRI 30329; paratype: PRI 30330. Type locality: locality 4.

Etymology.—The specific name *cribraea* (Latin, sieve), refers to the mesh-like ornamentation of the whorls.

Material examined.—Thirty specimens, the largest: 4.3 mm in length, 1.8 mm in width.

Subgenus **FIMBRIATELLA** Sacco, 1895, p. 37

Type species.—Cerithium fimbriatum Michelotti, 1847, by original designation. Miocene (Tortonian) of northern Italy.

Diagnosis.—Shell small, high; whorls carinate with spiral and axial sculpture, the intersections usually nodose; base flat with spiral threads, margined by a duplex spiral line, aperture oval to subquadrate, base weakly rostrate.

Remarks.—The genus ranges from the Paleocene to Pliocene.

Mathilda (Fimbriatella) iugum, new species
Plate 10, figures 8–9

Description.—Shell small, whorls six and a half, protoconch large, of two and a half smooth heterostrophic whorls set at an angle of about 30° from the shell axis. Spire whorls with four spiral lines, one defining the medial carina and two more, one above and one below quartering the whorls, and a weaker subsutural one; spirals intersected regularly with longitudinal lines that are nodular at their intersections. Base smooth or with obsolete spiral threads, flat, margined by a duplex line; aperture circular, columella concave and slightly thickened.

Remarks.—This species appears to have no close analogs in the Gulf coast Paleogene. To date the subgenus *Fimbriatella* has not been reported outside Europe where it is found from the Paleocene to the Pliocene, although Sohl (1960, p. 129) has remarked on the similarity of several Cretaceous Gulf coast species to this subgenus. Of those species I believe *Mathilda (Mathilda) ripleyana* Wade, 1926 is close enough to the type of subgenus *Fimbriatella* to be placed there. Sacco (1895, pp. 36–38) placed seven species in *Fimbriatella* of which *Mathilda (Fimbriatella) filogranata* Sacco, a *nomen nudum* from the Doderlein collection, is very close to *M. (F.) iugum,* differing primarily in possessing one extra spiral line on the shoulder; the type species of the subgenus *M. (F.) fimbriatum* is a little further removed with its more rounded whorls and prominent quadrate-shaped aperture.

Etymology.—Noting both the creek where it was found and the ridged whorls, *iugum* (Latin: ridge).

Type information.—Holotype: PRI 33080, 2.1 mm length; paratype: PRI 33089. Type locality: locality 4.

Material examined.—Eight specimens, the largest the holotype.

Genus **GLYPTOZARIA** Iredale, 1924, p. 248

Type species.—Turritella opulenta Hedley, 1907, by monotypy. Recent off Australia near Sydney.

Diagnosis.—Shell turriculate, whorls moderately rounded, with spiral lines and co-marginal axial ribs. Protoconch heterostrophic. Aperture ovate, with weak gutter.

Remarks.—Iredale defined the genus to draw attention to recent Australian turritellid specimens without a sinus in the outer lip; he also noted the occurrence of a fossil species in the Australian Eocene. Excepting the type, the genus is represented by two Recent species from Australian waters, *Glyptozaria columaria* Cotton and Woods, 1935, and *Glyptozaria euglypta* (Iredale, 1929). Wenz (1939, p. 653) follows Iredale, and places the genus in the Turritellidae, probably without knowledge of the protoconch. Cotton (1959, p. 358) moves it to the Turritellopsinae, a subfamily known to have a deviated but often immersed protoconch. MacPherson and Gabriel (1962, p. 99) place it in the present family, the Mathildidae.

Glyptozaria americana, new species

Plate 10, figures 12–14

Description.—Shell small, eight to ten whorls, protoconch heterostrophic, large, of two and a half smooth whorls, set at an angle of about 45° to the shell axis, junction with teleoconch whorls abrupt, delimited with an oblique rib. Spire whorls rounded, ornamented with six spiral lines, the strength and interlineal distance increasing from the upper to lower suture; the spiral lines crossed by numerous axial threads, forming a regular reticulate pattern, the intersections beaded. Body whorl with ten spiral lines, the sutural one the largest, the four or five basal ones closer together, the axial threads also weaker basally. Aperture ovate, outer lip thin, sometimes lirate within, carinate at the end of every rib; columella thickened, excavated and slightly reflected, slight emargination at the anterior end.

Remarks.—This species is unique in the North American Eocene although the Caribbean species *Mathilda plexita* Dall, 1896b, known from the Oligocene? to the Miocene? of Trinidad and Jamaica, is similar. That species has more prominently inflated whorls, four to six equally spaced spiral lines on the spire, an umbilical chink, and a more circular aperture. The basal spiral lines and concave columella of *M. plexita* probably means this species should also be assigned to *Glyptozaria.* In the North American Eocene, specimens of *Scalina trapaquara* Harris, 1895a that lack the protoconch may superficially resemble *G. americana* but the presence of basal spirals will separate the two. This species really points out the necessity of knowing the character of the protoconch, as without that knowledge the species would almost certainly have been assigned within the Scalidae.

Etymology.—Referring to the first occurrence in North America.

Type information.—Holotype: PRI 33078, 4.8 mm length; paratype: PRI 33079. Type locality: locality 4.

Material examined.—Two specimens, the largest 7.5 mm.

Family **ARCHITECTONICIDAE** Gray, 1850b, p. 64

Genus **PSEUDOMALAXIS** Fisher, 1885, p. 714

Type species.—Bifrontia zanclaea (Philippi, 1844a), by monotypy. Recent in the Mediterranean and off the Madeira Islands.

Diagnosis.—Shell planispiral, base weakly concave, whorls only lightly in contact or free, rim flat. Sculpture smooth, or with weak spiral or radial lines. Edge with crenulated cords, usually parallel to the axis but sometimes angulated. Aperture quadrilateral, edge sharp.

Remarks.—The genus ranges from the upper Cretaceous to Recent. Recent species are tropical or subtropical in distribution, and inhabit deeper waters.

Pseudomalaxis reklawensis, new species

Plate 10, figures 18–20

Description.—Shell medium-sized, to seven volutions. Whorls slightly concave on the upper and lower surfaces, the body whorl with vertical sides. Protoconch of about two smooth rounded whorls, the nucleus sunken and visible on the base, a fine cord differentiating it from the adult whorls. Whorls smooth above with prominent prosocline growth lines, suture impressed and bounded above by a large beaded cord, below with a similar cord. The lines of growth start at right angles to the sutures, then curve back at the middle of the whorl. Both upper and lower surfaces show very fine spiral striae. Aperture simple and rounded-quadrate in profile.

Remarks.—The closest species is *Pseudomalaxis texana* (Aldrich, 1911) from the Weches Formation, from which it may be distinguished by the lack of tuberculated rows in the center of the whorls and only a single beaded chord on the periphery. Both *Pseudomalaxis rotella* (Lea, 1833) from the Gosport Sand Formation, and *Pseudomalaxis plummerae* Palmer, 1937, from the Stone City beds are smooth, but are much smaller, without beading, and in the case of *P. plummerae* the final portion of the last whorl is bent out of the plane of coiling. This species is common in the Reklaw deposits, in contrast to the Weches and Cook Mountain Formations where species belonging to this genus are very rare.

Etymology.—Referring to the Reklaw Formation.

Type information.—Holotype: PRI 30336; paratype: PRI 30337. Type locality: locality 20.

Material examined.—110 specimens, the largest 1.1 mm thickness, 9.0 mm maximum diameter.

Pseudomalaxis? acuta, new species
Plate 10, figures 21–23

Description.—Shell medium in size (outer whorl missing), more robust than *Pseudomalaxis reklawensis* n.sp. Whorls flattened above and sharply concave below, the outer rim at an angle of 45° to the upper surface of the body whorl. The upper surface shows the faintest of revolving striae and has the suture bounded by a thick ribbed cord. The basal surface is smooth and shows radial wrinkles at the suture. The basal suture is bounded by a smaller cord than the one on the upper surface and this cord is margined by a ribbed line, the space between the cord and the line showing a few revolving striae.

Remarks.—This species has affinities with the Lower Eocene species *Pseudomalaxis verrili* (Aldrich, 1886); the latter, however, lacks the beaded ribs bordering the upper and lower edges of the body whorl. Another undescribed *Pseudomalaxis?* species occurs in the Wheelock Member of the Cook Mountain Formation in Texas; that species also has an acutely angled outer whorl, but is otherwise very smooth. None of these species fits very well within *Pseudomalaxis* s.l.; the genus *Mangonuia* Mestayer, 1930, would possibly be a better assignment but more material is first necessary for examination.

Etymology.—The specific name *acuta* (Latin, sharp), refers to the acute angular rim of this species.

Type information.—Holotype: PRI 30291. Type locality: locality 20.

Material examined.—One specimen, 5.1 mm in maximum diameter.

Genus **ARCHITECTONICA** Röding, 1798, p. 78

Type species.—Trochus perspectivus Linnaeus, 1758, by subsequent designation (Gray, 1847, p. 151). Recent in the Indo-Pacific.

Diagnosis.—Shell solid, umbilicate. Outline subdiscoidal to depressed-conic. First whorl of protoconch inverted, only the final smooth inflated volution visible on the apical surface. Whorls numerous, regularly increasing in size. Periphery rounded or carinate. Sculpture usually of spiral cords, which may be beaded. Aperture elliptical to subquadrate. Outer lip thin and sharp.

Remarks.—Recent species are few in number and restricted to warmer waters; the animals are carnivorous on sea anemones and corals. The genus is known from the Upper Cretaceous.

Subgenus **STELLAXIS** Dall 1892, p. 323

Type species.—Solarium alveatum Conrad, 1833a, by original designation. Upper Claibornian Gosport Sand Formation of Alabama.

Diagnosis.—Shell moderately large or large; spire smooth, suture impressed, margined above by a few spiral lines or grooves; keel sharply carinate; beneath smooth or weakly spirally striate, keel margined by a strong line; umbilicus wide, stellate; aperture rounded-rhombohedral.

Remarks.—The subgenus is known from the Paleocene and Eocene of North America.

Architectonica (Stellaxis) reklawensis, new species
Plate 11, figures 1–2

Description.—Shell large, subconical, of seven and three-eights to eight whorls. Protoconch of one and a half smooth whorls, later whorls smooth and convex below the suture and concave above it, the body whorl acutely carinated. Suture impressed and margined above with two revolving lines, the larger one defining the sutural edge. The first one to two adult whorls with indistinct radial wrinkles below the suture. Base smooth, or with spiral striae, convex near the umbilicus, and concave near the periphery, which is margined by a strong line. The umbilicus has strong radiating lines of growth which form weak folds at the umbilical carina. The interior profile of the whorl is subcylindrical with a posterior excavated area margined by a crenulated revolving line in the upper quarter.

Remarks.—This species is intermediate in position between *Architectonica sylvaerupis* (Harris, 1897a) and *Architectonica alveata* (Conrad, 1833a). *A. sylvaerupis,* a Lower Eocene species from the Hatchetigbee Formation, lacks the ventral line margining the carina and the umbilical margin is wrinkled rather than folded. Specimens of *A. alveata* from the Weches Formation in Texas differ in having more regular and larger radial umbilical folds and a tendency for the subsutural lines to become effaced at an early stage of growth. The Reklaw specimens keep the prominent subsutural lines at all growth stages. A characteristic of the later *A. alveata* group is the line in the center of the cylindrical umbilical area, prominently crenulated in those from the Jackson group; in the Weches specimens the line is in the lower third and in the

Reklaw specimens in the lower fifth. Palmer and Brann (1966, p. 499), separated the Jackson and Weches *A. alveata* specimens into unnamed subspecies. The folds on the first one to two adult whorls and the smooth upper surface are a characteristic of subgenus *Psilaxsis* Woodring, 1928, but the base lacks the channel margining the umbilical tubercles.

Etymology.—The specific name refers to the formation where the species is found.

Type information.—Holotype: PRI 30339; paratype: PRI 30340. Type locality: locality 20.

Material examined.—17 specimens, the largest (incomplete), 10.0 mm height, 28.6 mm maximum diameter.

Subgenus **PATULAXIS** Dall, 1892, p. 323

Type species.—Solarium scrobiculatum Conrad, 1833b, by original designation. Eocene, Upper Claibornian Gosport Sand Formation of Alabama.

Diagnosis.—Shell dorsally flattened, with funnel-shaped umbilicus and no umbilical rib, umbilical carina with tubercles; radial and spiral sculpture usually feeble or obsolete; periphery sharp, thin; suture usually crenulated.

Remarks.—The subgenus is known from the Upper Cretaceous to Eocene.

Architectonica (Patulaxis?) fimbriaea, new species

Plate 11, figures 3–5

Description.—Shell moderately elevated, flattened at the apex, the early whorls flat and depressed below the crenulated sutures. Later whorls increasingly flush with the suture, slightly sinuous in profile. Suture impressed, margined above by a broad elevated band which is regularly radially ribbed, above that a smaller revolving line and above that another larger crenulated one. The remaining surface covered with smaller flattened lines that are weakly noded where crossed by the sinuous growth lines, the growth lines increasing in size towards the suture above forming strong wrinkles, the intermediate subsutural line usually larger again. Base with concave body whorl, two spiral lines margining the crenulated periphery and many weaker ones that decrease in size with distance from the keel. Umbilicus wide, margin noded, whorls convex within. Aperture rounded rhombohedral.

Remarks.—The concave whorls, at least twice as wide as high, the ribbed cord under the suture and the smooth concave keel place this species in subgenus *Patulaxis.* The shape is between that of *Architectonica scrobiculata* and *Architectonica scrobiculata hicoria* Palmer, 1937, both from the Cook Mountain Formation. *A. scrobiculata* is more elevated, smooth or almost so, and the sutural lines are developed as swellings. The coarse noded sculpture is distinctive and will distinguish the new species from the two latter species. Palmer (1937, p. 171) noted *Patulaxis* is represented in the Arrialoor Cretaceous of India with *Solarium arctense* Stoliczka, 1868; *A. (P.?) fimbriaea* is closer to the Indian species than to *A. scrobiculata* and its varieties.

Etymology.—The specific name *fimbriaea* (Latin, fringe), refers to the radial wrinkles fringing the suture.

Type information.—Holotype: PRI 30341. Type locality: locality 20.

Material examined.—Three specimens, the largest: 8.0 mm width, 16.2 mm maximum diameter.

Subgenus **GRANOSOLARIUM** Sacco, 1892, p. 59

Type species.—Solarium millegranum Lamarck, 1822, by original designation. Middle and Upper Miocene of the Piedmont of Italy.

Diagnosis.—Shell with upper portion of whorl convex, lower part concave, peripheral keel sharp. Dorsal surface ornamented by beaded spiral lines of various strengths. Ventrally ornamented with spiral lines, excavated in front of the keel; umbilicus large, margin with nodes or coarse crenulations.

Remarks.—The subgenus ranges from the Upper Cretaceous to Recent.

Architectonica (Granosolarium) aldrichi caterva, new subspecies

Plate 11, figures 6–8

Description.—This species is similar enough to *Architectonica (Granosolarium) aldrichi* (Dall, 1892) from the Middle Eocene Weches Formation to be regarded as a subspecies, but is distinguished by its generally coarser sculpture. The basal ornamentation of three revolving spiral ribs and two lines of strong umbilical tubercles is similar to *A. (G.) aldrichi,* except that in the Reklaw material the inner row of tubercles is larger than the outer one and less numerous, in a ratio of about 1:3. Instead of three broad flat spirals and three threads margining the umbilical carina there are four broad flat spirals, the innermost one being the largest. On the upper surface the spiral lines are broader and become smooth on the body whorl, but the number of lines is the same as in *A. (G.) aldrichi* s.s.

Etymology.—The subspecific name *caterva* (Latin, crowd), refers to the crowded character of the spiral lines.

Type information.—Holotype: PRI 30338. Type locality: locality 20.

Material examined.—17 specimens, the largest 3.4 mm thickness, 7.1 mm maximum diameter.

Architectonica (Granosolarium) geminicostata, new species

Plate 11, figures 9–10

Description.—Shell medium sized, of six and three-quarters whorls, cyrtoconoid in shape and acute on the margin. The whorls of the upper surface are weakly sinuous in profile, the concavity above the suture with two strong lines and the larger whorls developing a weaker intermediate line and generally with four to five smaller lines above that. Early whorls strongly beaded, the beading tending to become obsolete on the body whorl in large specimens. Area between the lines with regular microscopic oblique striae visible only under the microscope. Keel defined by a strong line. Base excavated near the margin and crossed by spiral lines that increase in strength towards the umbilicus, the final three generally crenulated, the area within the umbilicus showing two further crenulated ribs, the three ribs dividing the whorl area into thirds. Lines of growth within the umbilicus nearly vertical to the uppermost rib where they then swing obliquely forward.

Remarks.—A. (G.) geminicostata resembles the middle Claibornian representative, *Architectonica (Granosolarium) meekana* Gabb, 1860 from the Stone City beds and the Cook Mountain Formation; both species are quite variable in form. On some specimens the lines on the upper surface coalesce to form a broad band; spiral striae or thin lines may appear on both upper and basal surfaces; the strengths of the various lines may vary considerably within the group. Characters which are constant are the three lines on the base under the suture and the two crenulated ribs within the umbilicus. This last feature does not seem to be duplicated in any other *Architectonica* sp. within the Claibornian of the Gulf Coastal plain. On the dorsal surface *A. (G.) geminicostata* can be differentiated from *A. (G.) meekana* and subspecies by the more equal-sized spiral lines with the much weaker beading.

Etymology.—The specific name *gemini-* (Latin, twins), *costata* (Latin, rib), refers to the pair of ribs in the umbilicus.

Type information.—Holotype: PRI 30342; paratype: PRI 30343. Type locality: locality 20.

Material examined.—59 specimens, the largest 7.5 mm width, 18.0 mm maximum diameter.

Genus **TRIMALAXIS**, new genus

Type species.—Omalaxis singleyi Aldrich, 1890, herein. Claibornian Eocene of Texas.

Diagnosis.—Shell small to very small, protoconch heterostrophic, ornamented with faint collabral lines, transition to teleoconch as in other Architectonicidae. Teleoconch whorls barely in contact, sutural depression deep, strongly tricarinate with one central peripheral carina, one each on the upper and lower whorl surfaces, intracarinal area smooth or with faint growth lines or threads.

Remarks.—Omalaxis Deshayes, 1830, was defined for a group of shells with multicarinate whorls, basally rounded, the last whorl usually somewhat free and bent out of the plane of coiling. Wenz (1944) places the genus questionably in family Omalaxidae and notes the protoconch was not heterostrophic, unlike that of *Trimalaxis*. Bieler (1984), in his revision of the genus *Pseudomalaxis,* notes that the Eocene species of *Omalaxis* from the Paris Basin have orthostrophic protoconchs, and should be represented by a separate family, the Omalaxidae; the recent species assigned to *Omalaxis* he transfers to *Pseuodomalaxis*; he regards *Omalaxis singleyi* though, as belonging to an undescribed genus in the family Architectonicidae. In the genus *Pseudomalaxis* one other species, *Pseudomalaxis (Spirolaxis) cornuammonis* (Melvill and Standen, 1903), also has a sharp peripheral carina, but in that species the whorls form a wide open spiral and are bent out of the plane of coiling. Recent species of *Spirolaxis* Monterosato, 1913, are differentiated from species of *Pseudomalaxis* s.s, not only by the open whorls but also by their very different operculums. *Trimalaxis* is apparently an offshoot of *Pseudomalaxis* where the teleoconch whorls are derived from the latter by a rotation about the apertural axis by 45°; the remaining teleoconch characters between the two are very similar. The generally close relationship to *Pseudomalaxis* is also noted by the very similar protoconch whorls.

Trimalaxis ora, new species

Plate 11, figures 11–12

Description.—Three and a quarter whorls; nuclear whorls two and a quarter, deviated, initially smooth, gradually developing pronounced riblets. A strong flange ends the nuclear whorls that on the basal surface is folded back over itself. Postnuclear whorls with three strong, square-topped carinal cords overridden by growth lines that regularly increase in size as they approach the outer two carinae and there form nodes at the intersections with the cords. Whorls strongly concave between the peripheral carina and the two adjoining ones, convex on the upper and lower surfaces, in contact at the central carina only. Aperture square-ovate, feebly oblique towards the basal side.

Remarks.—This species is distinguished from *Trimalaxis singleyi* (Aldrich, 1890) by the strongly concave whorl area adjoining the periphery, the smooth peripheral carina, and different apertural shape. The type and all other Middle Claibornian specimens examined have a crenulated peripheral carina. Palmer and Brann (1966) report only the one species *T. singlei*, from a single location in Lee County, Texas. The author has found the genus to be uncommon but widely distributed in the Cook Mountain and Weches Formations of Texas.

Etymology.—Noting the prominent peripheral rim of this species.

Type information.—Holotype: PRI 30344. Type locality: locality 4.

Material examined.—One specimen, 1.8 mm maximum diameter.

Family **TEREBRIDAE** Mörch, 1852, p. 74

Subfamily **TEREBRINAE** Mörch, 1852, p. 74

Genus **HASTULA** H. and A. Adams, 1853, p. 225

Type species.—*Terebra strigillata* Linnaeus, 1758, by subsequent designation (Cossmann, 1896b, p. 53). Recent in the Indo-Pacific.

Diagnosis.—Whorls high, smooth; axial crenulations below the suture, or slender ribs not developed into nodes; no spiral sculpture except for a subsutural groove; siphonal fasciole margined by a line; columella simple, straight, produced anteriorly; outer lip sharp, almost straight.

Remarks.—Bratcher and Cernohorsky (1987) monograph the recent Terebridae and conclude, that "It is impossible to devise groupings based on shell characters alone, where there is little or no doubt as to which group a species belongs". They recognize just four genera, including *Hastula*. The closely similar genus *Terebra* Bruguière, 1789, is also found in the Eocene. *Terebra* can be separated by its usually larger size, relatively small last whorl, columella not elongated, aperture squarish-ovate, and sculpture often with strong spiral and/or axial riblets. The genus ranges from the Eocene to Recent.

Subgenus **HASTULA** s.s.

Hastula (Hastula) milamensis, new species

Plate 22, figures 7–8

Description.—Shell very small, high, of eight and one-half whorls. Protoconch of four whorls with the suture margined above and below by a faint line, first three and three-quarter whorls rounded, the last cylindrical and of smaller diameter than the preceding. Adult whorls with a swollen subsutural band, excavated below and with subsutural folds that tend to be nodose below the suture, the folds stronger on early whorls. Columella smooth and straight on the midsection, anteriorly twisted and with a shallow notch. Siphonal fasciole indistinct and margined by a line or groove.

Remarks.—This is close to *Hastula houstonia* (Harris, 1895a) from the Cook Mountain Formation, differing from it by the straighter whorls, much weaker ornamentation and the larger more conical protoconch. The body whorl is also noticeably more rounded than on the Reklaw species.

Etymology.—The specific name notes the occurrence in Milam County, Texas.

Type information.—Holotype: PRI 30506; paratype: PRI 30507, 30508. Type locality: locality 20.

Material examined.—115 specimens, the largest: 8.3 mm length, 2.1 mm width.

Subgenus **BULBIHASTULA,** new subgenus

Type species.—Hastula (Bulbihastula) ampulla.

Diagnosis.—Whorls weakly to moderately convex, broadly excavated below the suture, no subsutural spiral band. Ornament of prominent, longitudinal folds and little or no spiral ornament. Aperture a little longer than in *Hastula* s.s. and with a weak siphonal fasciole margined by a line, no columellar folds, anterior end feebly notched.

Remarks.—This subgenus would appear to include species such as: *Terebra (Myurella) basterot* Nyst, 1843, several subspecies of *Hastula striata* (Basterot, 1825), *Hastula benoisti* (Peyrot, 1932), and a common but so far undescribed species from the Cook Mountain Formation in Texas. On the above basis the subgenus would range from the Eocene to the Mocene.

Hastula (Bulbihastula) ampulla, new species

Plate 22, figures 9–10

Description.—Whorls eight to nine, protoconch conical, of three and one-half smooth whorls, slightly heterostrophic, the height and greatest diameter equal. Whorls moderately inflated, with 15 to 21 longitudinal ribs that run the entire length of the whorl, and tend to become nodose above the subsutural excavation. Columella excavated above and bent towards the short, wide canal. Anterior notch very shallow.

Remarks.—Specimens of *Terebra (Myurella) basterot* Nyst, 1843, from the Miocene of northern Italy, which were examined at the Natural History Museum, London are similar, have a different protoconch, but the same number of very laterally compressed straight whorls, and a subsutural line not crossing the ribs. The subsutural line is absent or obsolete in the Reklaw specimens but the type of sculpture and apertural shape are very similar. There appear to be no North American species close enough for a meaningful comparison.

Etymology.—The specific name *ampulla* (Latin, vase), refers to the shape of the body whorl.

Type information.—Holotype: PRI 30509; paratypes: PRI 30510–30513. Type locality: locality 20.

Material examined.—130+ specimens, the largest: 8.0 mm length, 2.7 mm width.

Hastula (Bulbihastula) longifera, new species
Plate 22, figures 11–12

Description.—Shell long, narrow, of nine and one-half slightly convex whorls, subsutural excavation slight to non-existent. Protoconch of three and one-half smooth whorls, higher than wide, nucleus minute and heterostrophic. Adult ornament of numerous low longitudinal folds becoming obsolete below. Columella smooth, straight posteriorly and somewhat abruptly bent below. Anterior notch very small and shallow.

Remarks.—This species can be separated from *Hastula (Bulbihastula) ampulla* by its almost straight sided whorls, and more numerous axial riblets, which become weaker on the lower portion of the whorls. Another similar species is *"Hastula" venusta* (Lea, 1833), which is shorter, has minute spiral striae between the ribs, and a more oblique columella.

Etymology.—The name *longifera* (Latin, lines), refers to the longitudinal ribs on the whorls.

Type information.—Holotype: PRI 30514; paratypes: PRI 30515, 30516. Type locality: locality 20.

Material examined.—13 specimens, the largest: 9.7 mm length, 2.2 mm width.

Subclass **EUTHYNEURA** Spengel, 1881, p. 372

Order **CEPHALASPIDEA** Fisher, 1883, p. 550

Superfamily **CYLICHNIDOIDEA** H. and A. Adams, 1854, p. 9

Family **CYLICHNIDAE** H. and A. Adams, 1854, p. 9

Genus **MNESTIA** H. and A. Adams, 1854, p. 10

Type species.—Bulla marmorata A. Adams, 1849, by subsequent designation (Cossmann, 1895, p. 99). Recent in the Philippines.

Diagnosis.—Shell ovately cylindrical, transversely striated, the lines stronger, and wider apart at the ends; spire conspicuous, immersed in the deep umbilicus at the apex; aperture narrow, acuminately produced, both above and below; outer lip solid; columella short, concave, and reflected against the basal whorl.

Remarks.—The genus ranges from the Eocene to Recent.

Mnestia rotunda, new species
Plate 22, figures 17–18

Description.—Shell small, thin. Shape oval, smoothly rounded above and below, body whorl below the apex minutely truncate. Surface with spiral striae on the base and a few on the apical end. Umbilicus small and partially obscured by the outer lip, which thickens ridge-like at the edge as it meets the columella. Aperture thin above and medially, wider below and bent prominently to the left.

Remarks.—Easily separated from other forms due to its more rounded form; far nearer to the type of the genus than are any of the other American Eocene representatives. The common species, *Mnestia dekayi* (Lea, 1833) from the Cook Mountain Formation, is conical, tapering posteriorly. This occurrence extends the lower range of the genus to the Reklaw Formation from the Cook Mountain Formation.

Etymology.—The name *rotunda* (Latin, globular), notes the very inflated form of this species.

Type information.—Holotype: PRI 30517; paratype: PRI 30518. Type locality: locality 20.

Material examined.—19 specimens, the largest: 2.6 mm length, 1.1 mm width.

Mnestia confusa, new species
Plate 22, figures 13–14

Description.—Shell very small, asymmetrically elliptical or ovate, maximum diameter submedial. Aperture curved, wider below and bent to the left both above and below, slightly reflected below. Outer lip smoothly curved below, straightening out above, except for a slight thickening where its meets the anterior portion of the margin at the lower umbilicus. Surface smooth with faint spiral lines on the base of the body whorl and fainter ones below the apex, medial area with microscopic longitudinal lines of growth.

Remarks.—This species approaches *Bulla* s.s. in shape, particularly the recent *Bulla eburnea* Dall, 1881, of Florida and the West Indies. It can be distinguished from *Mnestia rotunda* n.sp. by its shorter and more globose shape and the asymmetrical shape of the body whorl. The species also has characteristics of the genus *Abderospira* Dall, 1896a, in the apertural shape.

Etymology.—The specific name *confusa* (Latin, confused), refers to the resemblance to genus *Bulla*.

Type information.—Holotype: PRI 30519. Type locality: locality 4.

Material examined.—24 specimens: the largest 2.5 mm length, 0.8 mm width.

Family **RETUSIDAE** Thiele, 1925, p. 106

Genus **VOLVULELLA** Newton, 1891, p. 268

Type species.—Bulla acuminata Bruguière, 1792, by subsequent designation (A. Adams, 1862). Recent, European seas.

Revised diagnosis.—Shells small, tapering, ovate or subcylindrical; aperture narrow, elongate, rounded basally and extending the entire length of the shell. There is no columellar lamella or other apertural dentition. At its apical end the aperture bends over the apex of the shell, and the parietal wall here forms a spine which completely covers the apex, so that only the final whorl is visible (after Harry, 1967, p. 134).

Remarks.—Palmer (1937, pp. 492–495) recognizes seven species of *Volvulella* from the Claibornian Eocene; these were reassigned to *Rhizorus* Montfort, 1810 by Palmer and Brann (1966). Harry (1967, pp. 133–135) shows that *Rhizorus* cannot be used as a substitute, so *Volvulella* must be reinstated. Montfort's species would appear to apply to shells similar to *Mnestia*. The genus ranges from the Paleocene to Recent.

Volvulella reklawensis, new species

Plate 22, figures 15–16

Description.—Shell small. Anteriorly subconical, straight-sided below the maximum diameter, anterior lip prominently protruding from a rear view. Posterior end drawn out into a channeled spire. Outer lip almost straight medially, thin above, thickening greatly below. Inner lip thickened, reflected partially over the small umbilicus; anterior edge of the outer lip duplex, then splitting, the edges bounding each edge of the umbilicus. Below, the aperture flares widely and forms an incipient fold. Surface medially smooth, with spiral lines on each end and a few short obscure longitudinal lines.

Remarks.—The closest species is *Volvulella loisae* Palmer, 1937, from which it can be separated by the more tapering extremities, and the narrower aperture which is anteriorly bent to the left. Another similar, slender species is *Volvulella conradiana* (Gabb, 1860) which is more cylindrical with a shorter posterior spine. The rotund *Volvulella minutissima* (Gabb, 1860) also exhibits the duplex character of the basal edge but to a far lesser degree. This occurrence extends the lower range of the genus from the Middle to the Lower Claibornian.

Etymology.—The specific name refers to the formation in which it occurs.

Type information.—Holotype: PRI 30520. Type locality: locality 20.

Material examined.—Four specimens, the largest: 2.9 mm length, 1.0 mm width.

Genus **RETUSA** Brown, 1827, pl. 38, figs. 5, 6

Type species.—Retusa crassa Montague, 1803, by original designation. Recent off the coast of Great Britain.

Diagnosis.—Shell small, cylindrical-pyriform, spire low, sunken or involute. Aperture half the total length of the shell, posteriorly narrow, anteriorly flaring. Columellar fold weak to absent. Last whorl smooth, or with fine spiral striae, labrum usually opistocline at suture.

Remarks.—Zilch (1959, p. 45) gives the range of *Retusa* as Jurassic to Recent.

Subgenus **CYLICHNINA** Monterosato, 1884, p. 143

Type species.—Cylichnina laevisculpta, Granata, 1877, by original designation. Recent in the western Mediterranean.

Diagnosis.—Shell small to very small; cylindrical to ovate; spire depressed, previous whorls not visible; body whorl posteriorly rounded, usually anteriorly spirally striate, sometimes entirely so; aperture narrow, long, higher than the apex; columella excavated, usually with a fold.

Remarks.—Palmer (1937, p. 479), Gardner (1945, p. 265), and most authors prior to 1952 regard *Cylichnina* as a subgenus of *Cylichna,* Lovén, 1846. Since Eames (1952), authors have regarded *Cylichnina* as a subgenus of *Retusa.*

Retusa (Cylichnina) notata, new species

Plate 22, figures 19–20

Description.—Shell small, ovate-cylindrical. Surface covered with fine spiral striae which are more prominent on both ends; medially the lines are less conspicuous but double in number due to intermediate striae. Outer lip thin, sharp and almost straight. Inner lip thickened below the small umbilicus, thinning gradually posteriorly and abruptly anteriorly at the junction with the outer lip. Aperture long, slightly constricted at the posterior third of the body whorl, wider below and bent to the left. Under the microscope the thickened labial ridge is seen to have minute transverse lirae on the summit.

Remarks.—This species has close affinities with both *Retusa (Cylichnina) galba* (Conrad, 1833a) and *Retusa (Cylichnina) kellogii* (Gabb, 1860), but can be distinguished from both of the preceding by the more slender outline, the smoothly rounded posterior end rather than the flat top of those species, and the lirate labial ridge. The Sabinian species *Retusa sylvaerupis* (Harris, 1899) is slightly conical, wider than *R. (C.) notata* and has a columellar depression with incipient folds on either side.

Etymology.—The name *notata* (Latin, markings), refers to the spiral lines covering the entire surface of the whorls.

Type information.—Holotype: PRI 30521; paratypes: PRI 30522, 30523. Type locality: locality 20.

Material examined.—Eight specimens: the largest 6 mm length, 1.8 mm width.

Retusa (Cylichnina) cf. **adamski** Palmer, 1937
Plate 22, figures 21–22

Cylichnina adamski Palmer, 1937, p. 482, pl. 75, figs. 22, 23; Brann and Kent, 1960, p. 301; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, p. 20.
Retusa (Cylichnina) adamski Palmer and Brann, 1966, p. 877.

Original description.—"Shell small; perforate; posterior end truncated; sides of the shell nearly parallel; aperture narrow posteriorly; columellar callus has a twist or fold which varies with specimens—on some specimens only a trace is seen—back of the twist is a groove; surface smooth except for a few microscopic spiral lines anteriorly." (Palmer, 1937, p. 482)

Remarks.—The Reklaw specimens are slightly slenderer than typical *R. (C.) adamski* s.s.

Type information.—Holotype: PRI 3388. Figured Reklaw specimen: PRI 30551, from locality 4.

Material examined.—Six Reklaw specimens, numerous Cook Mountain ones.

Family **RINGICULIDAE** Philippi, 1853, p. 190

Genus **RINGICULA** Deshayes, 1838, p. 342

Type species.—Auricula ringens Lamarck, 1804, by subsequent designation (Gray, 1847a, p. 140). Eocene of the Paris Basin.

Revised diagnosis.—Shell small, oval to globose, spire moderate in extent. Protoconch heterostrophic, deviated, nucleus partially immersed. Whorls inflated, ornament usually of punctate spiral striae, suture impressed. Aperture auriform, contracted above, notched basally. Outer lip varicose, dentate; labrum thickened, toothed above; columella with two folds, the lower one defining the basal edge.

Remarks.—The genus ranges from the Upper Cretaceous to the present where it is abundantly represented in temperate and tropical waters, usually at depths of over 50 fathoms. The animals are reported to be carnivorous on polychaete worms and foraminifera.

Ringicula trapaquara Harris, 1895a
Plate 22, figures 23–24

Ringicula trapaquara Harris, 1895a, p. 53, pl. 3, fig. 7; Aldrich, 1897, p. 8, pl. 2, fig. 7; Gardner, 1933, p. 211; Palmer, 1937, p. 476, pl. 73, fig. 8; Palmer and Brann, 1966, p. 884; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, p. 11.

Original description.—"Whorls five; whorls one, two and three nearly or quite smooth; four with a well marked subsutural line and fainter ones over the whorl surface; body whorl striate spirally, labrum very much thickened and crenulate within, labial callosity very pronounced, the labial plicae strong and ascending rapidly over the body whorl." (Harris, 1895a, p. 53)

Remarks.—The Reklaw specimens of *R. trapaquara* s.s. are somewhat thinner shelled, develop the spiral ornament earlier and show less development of callus than *R. trapaquara* s.s from the type locality. The number of spiral lines is the same in specimens from the Cook Mountain Formation and the Reklaw Formation, although in the latter group, the lines are smaller and more regularly spaced. The strength of the spiral ornament appears to be of little importance as a differentiating character in specimens of *R. trapaquara* from the Stone City Member of the Cook Mountain, as the spiral ornament ranges from being quite smooth to strongly striate. Several specimens from Ridge Creek are altogether more elongate, exhibiting more pronounced labial callosity than the remainder and might represent a new species; these specimens came from a thin sandy lens within an area where the clay is quite black, has an almost waxy consistency, and is otherwise quite featurless. No other molluscs were found in this area. Until more specimens are collected it is not known if this represents a distinct group.

Type information.—Holotype: TBEG 35572. Type locality: San Antonio Ferry, Burleson County, Texas. Range: Middle Eocene, Stone City beds. Figured Reklaw specimen: PRI 30524, from locality 14.

Material examined.—34 specimens, the largest: 2.4 mm length.

Family **PHILINIDAE** Gray, 1850b, p. 94

Genus **PHILINE** Ascanius, 1772, p. 331

Type species.—Bulla aperta, Linnaeus, 1767, by monotypy. Recent seas of the British Isles.

Diagnosis.—Shell thin, fragile, loosely enrolled; spire small, often hidden; body whorl smooth or spirally striate, greatly expanded anteriorly; outer lip rounded.

Remarks.—Philine species are carnivorous on small molluscs below the sea bed, usually at moderate depths. The genus ranges from the Upper Cretaceous to Recent.

Philine sp.
Plate 22, figure 25

Remarks.—Two specimens of this genus were obtained; they are very similar to *Philine (Megistostoma) gabbianum* (Stoliczka, 1868) from the Middle Eocene of California. The almost complete example is embedded and somewhat flattened, in a block of matrix hiding the apertural view. The posterior view outline is closely similar to that of *P. (M.) gabbianum,* the surface is smooth with spiral threads, closely spaced near the apex becoming more widely spaced and duplex in character towards the anterior; edge of the outer lip at the apex is thickened. An apical fragment was also obtained which may represent this species. Two species are reported from the Gulf Coast Eocene, *Philine alabamensis* Aldrich, 1897, from the Sabinian Eocene at Wood's Bluff and *Philine (Megistostoma) dockeryi* Allen, 1970, from the Moody's Branch Upper Eocene of Mississippi; *P. alabamensis* has fine, zigzag spiral lines and *P. (M.) dockeryi* has much stronger spiral sculpture which becomes less crowded towards the apex.

Figured specimen: PRI 30404, from locality 4.

Material examined.—Two specimens, the figured specimen 19 mm length.

Superfamily **ACTEONOIDEA** Cernohorsky, 1972, p. 203

Family **ACTEONIDAE** d'Orbigny, 1842b, p. 106

Genus **ACTEON** Montfort, 1810, p. 314

Type species.—Voluta tornatilis Linnaeus, 1758, by original designation. Recent in European seas.

Diagnosis.—Shell usually small to very small, profile ovate to elliptical in shape. Protoconch usually not entirely visible, the tip enrolled. Whorls rounded, suture impressed, sometimes channeled; sculpture of punctate spiral lines. Aperture long, contracted above, basally expanded and rounded. Outer lip thin, labrum with one fold which is the continuation of the basal edge.

Remarks.—Acteonids are regarded as the most primitive living opisthobranchs; the group is worldwide in distribution in temperate and tropical waters in moderate depths; the animals are carnivorous on polychaete worms. The genus is widely distributed form the Upper Cretaceous to Recent.

Acteon pomilis punctatus I. Lea, 1833
Plate 22, figures 28–29

Acteon punctatus I. Lea, 1833, p. 111, pl. 4, fig. 96; H.C. Lea. 1849, p. 95; de Gregorio 1890, p. 165, pl. 16, fig. 21 copy Meyer, fig. 22 copy Lea; Harris 1895c, p. 37, not *Tornatella punctata* Férussac, 1823 (in: 1819–1832), p. 112 (= *T. sulcata* Gmelin); not d'Orbigny in Sagra (1842c), p. 230.

Acteon punctatus I. Lea. Conrad, 1865a, p. 34; 1866a, p. 9; Meyer, 1885, p. 468; Dall, 1892, p. 14 in part; Cossmann, 1893, p. 48 as *Actoean*; Cossmann, 1895, p. 46.

Acteon inflatior Meyer, 1886, p. 78, pl. 2, fig. 31; Cossmann, 1893, p. 48.

Actaeonida (Rictaxsis) punctatus (I. Lea). Cossmann, 1895, p. 52.

Acteon pomilis punctatus I. Lea. Palmer, 1937, p. 499, pl. 74, figs. 25, 29, 31, 35, 36; pl. 90, fig. 2; Brann and Kent, 1960, p. 24; Palmer and Brann, 1966, p. 482; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, p. 10, p. 28.

Original Description.—"Shell ovately conical, transversely and closely furrowed; furrows closely set with punctures; substance of the shell rather thick; spire rather elevated, pointed; suture somewhat impressed; columella with one fold; whorls five; mouth narrow, about three-fifths the length of the shell; outer lip thickened about the middle. Length 7–20ths, Breadth .2 of an inch." (I. Lea, 1833, p. 111)

Remarks.—The Reklaw specimens appear to differ in very few respects from *A. p. punctatus* as developed in the Stone City and Landrum members of the Cook Mountain Formation. The shell is slightly more elongate, possesses flat-topped ribs and has a weaker, more oblique columellar fold. Even though these differences are constant, they are within the range of variability of the species as exhibited by specimens in the Weches through Gosport Sand formations, and thus not deserving of separate taxonomic rank. Specimens assigned to the species *A. pomilis punctatus* show a steady development of more rounded ribs throughout Claibornian times, a sequence that ends with *Acteon annectens* Meyer, 1885.

Type information.—Holotype: ANSP 5537. Holotype *Acteon inflator* Meyer, 1886: USNM 638840. Type locality: Claiborne Bluff, Alabama river, Gosport Sand Formation. Figured Reklaw specimen: PRI 30525, from locality 4.

Material examined.—30 specimens, the largest: 5.5 mm length, 3.0 width.

Genus **SEMIACTEON** Cossmann, 1889, p. 304

Type species.—Tornatella sphericulus Deshayes, 1864, by original designation. Lutetian Eocene of the Paris Basin.

Original Diagnosis.—"Coquille ombiliquée, globuleuse, à embryon obtus et mamillé, à ouverture entière et arrondie; labre épais, avec un bourrelet obsolète a l'extérieur; columelle droîte, un peu renflée au milieu, se terminant en point à sa jonction avec le bord antérieur. Type: *Tornatella spaericula,* Desh." Translation: Shell umbilicated, inflated; protoconch obtuse and mammilate; aperture entire, rounded; outer lip sharp; with an obsolete callus pad; columella straight, a weak fold in the middle, terminated anteriorly at the base.

Remarks.—The strong collabral lines forming a cancellate ornament and the shorter anteriorly rounded aperture can also be used to distinguish this genus from *Acteon* s.s.. *Semiacteon* has not hitherto been reported outside of Europe where it is represented by a few species ranging from the Eocene to the Miocene. A similar genus is *Kleinacteon* Vokes, 1939, which was placed doubtfully in the Acteonidae by Vokes due to the "smooth, somewhat naticoid" nucleus. MacNeil (in MacNeil and Dockery, 1984, p. 230) places *Kleinacteon* in the Acteonidae, surmising that Vokes may have failed to recognize the obscurely heterostophic nature of the nucleus. If the nucleus is heterostrophic there appears to be no essential difference between *Semiacteon* and *Kleinacteon*.

Semiacteon texanum, new species
Plate 22, figures 26–27

Description.—Shell small, elongate, of about five whorls. Protoconch large, tip enrolled and not visible. Sculpture of fine, flat-topped spiral lines of equal strength, spaced somewhat wider apart on the subsutural ramp, crossed by fine, longitudinal threads forming a cancellate pattern. Where the threads cross the spirals they bend sharply forward so the entire pattern is slightly offset from thread to thread. Aperture elongate-ovate with a slight spout, outer lip sharp, straight at the mid-section, and considerably thickened behind the rim. Columella thickened at the base of the body whorl into an obtuse incipient fold that decreases in strength as it spirals into the aperture. Umbilical chink present.

Remarks.—The sculpture is similar to that of species of *Acteon* s.s. but the latter have wide flat ribs with narrow interstices whose longitudinal threads are only visible within the grooves, thus generating a punctate pattern. The present sculpture, apertural shape and weak fold on the columella assign the species to *Semiacteon.* In the acteonids examined from the Claiborne Group two types of protoconchs occur; the first is smaller, about half the size of the second, having the initial heterostrophic turn rising above the remaining part of the protoconch and forming a blunt conical profile; the second is much larger and has the initial turn fully immersed. I believe these two groups deserve at least subgeneric rank. The paratypes of *A. idoneus* in the Academy of Natural Sciences in Philadelphia, belong to the taxon possessing the second type of protoconch, and indeed is the same type as *Semiacteon (=Kleinacteon).* The most similar species is *Semiacteon puteatus* (MacNeil, 1984) from the Mint Spring Oligocene of Mississippi; that species can be differentiated by the more rounded whorls, thinner spiral ribs, and prominent anterior spout.

Etymology.—The name refers to the occurrence in Texas.

Type information.—Holotype: PRI 33078. Type locality: locality 4.

Material examined.—Two specimens: the largest (the holotype) 4.5 mm length.

Order **ENTOMOTAENIATA** Cossmann, 1896b, p. 5

Superfamily **PYRAMIDELLOIDEA** Gray, 1840, p. 152

Family **PYRAMIDELLIDAE** Gray, 1840, p. 152

Genus **PYRAMIDELLA** Lamarck, 1799, p. 76

Type species.—Trochus dolabratus Linnaeus, 1758, by original designation. Recent off the coast of Florida and the West Indies.

Diagnosis.—Shell elongate-conic, whorls increasing regularly in size; two or three folds on the columella. The shell is usually strongly polished and porcellaneous in luster (after Dall and Bartsch, 1909, p. 8).

Remarks.—The distribution is world wide with many species ectoparasitic or carnivorous on polychaete worms, coelenterates and molluscs. The genus ranges from Paleocene to Recent. As Dall and Bartsch (1904) note, their grouping of the family Pyramidellidae is in many respects only a practical and convenient one. This has led to a somewhat artificial placement of the Reklaw specimens since species described herein often have some characters belonging to more than one subgenus. For convenience, however, their division of the group has been followed. The genus and the subgenera treated here are known throughout the Tertiary and are worldwide in distribution.

Subgenus **SYRNOLA** A. Adams, 1860, p. 405

Type species.—Syrnola gracillima A. Adams, 1860a, by original designation. Recent off the coast of Korea.

Diagnosis.—Shell slender, medium sized; one columellar fold, shell not umbilicated; surface marked by fine lines of growth and microscopic spiral lines, axial sculpture lacking; protoconch heteroscopic, nucleus central, exsert; postnuclear whorls increasing regularly in size.

Pyramidella (Syrnola) pirum, new species
Plate 23, figures 1–2

Description.—Shell small and slender. Whorls 10, protoconch of one and one-half whorls at right angles to the shell axis and partially immersed in the succeeding whorl. Adult whorls smooth, straight-sided or feebly concave below the deeply impressed suture and curving smoothly inward to the lower suture. The strength of the sutural depression varies with age, later whorls being more strongly impressed, generating a prominently rounded lower whorl profile. Body whorl prominently rounded below a slight basal keel, outer lip smooth within, aperture tear-drop shaped, inner lip reflected below and uniting with a basal columellar fold. Small umbilical depression present.

Remarks.—This species most closely approaches *Pyramidella (Cossmannica) perexilis* (Conrad, 1865a), from the Cook Mountain and Gosport Sand formations, but is much smaller and is placed in section *Syrnola* instead of *Cossmannica* due to the lack of a second columellar fold. None of the specimens shows even a trace of a second fold.

Etymology.—The specific name *pirum* (Latin, pear), refers to the pear-shaped aperture.

Type information.—Holotype: PRI 30526; paratypes: PRI 30527, 30528. Type locality: locality 20.

Material examined.—21 specimens, the largest: 3.5 mm length, 0.7 mm width.

Subgenus **COSSMANNICA** Dall and Bartsch, 1904, p. 6

Type species.—*Pyramidella clandestina* Deshayes, 1861, by original designation. Eocene (Cuisian and Thanetian) of the Paris Basin.

Diagnosis.—Columellar folds two; shell not umbilicated, surface polished, marked by fine lines of growth and microscopic spiral striations; basal fasciole absent; aperture suboval (after Dall and Bartsch, 1909, p. 10).

Remarks.—Dall and Bartsch separated this subgenus from *Syrnola* solely on the basis of the suboval shape of the apertural.

Pyramidella (Cossmannica) perexilis (Conrad, 1865a)

Plate 23, figures 3–4

Obeliscus perexilis Conrad, 1865a, p. 28.
Odostomia perexilis (Conrad). de Gregorio, 1890, p. 157, pl. 15.
Syrnola perexilis (Conrad). Dall, 1892, p. 247.
Pyramidella perexilis (Conrad). Palmer, 1937, p. 75 in part, pl. 7, figs. 4, 5, 21; Palmer and Brann, 1966, p. 869; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, p. 20, 32

Original description.—"Subulate, polished; volutions fourteen; sides straight above and rounded at base; suture deeply channeled; body whorl with slightly concave sides; columella with a prominent plait uniting with the labial deposit." (Conrad, 1865a, p. 28)

Remarks.—The Reklaw specimens are very close to *P. (C.) perexilis* s.s. from the Middle Claibornian, differing mainly in the less prominent contraction of the body whorl above the suture. They possess a well-defined second fold that starts within the aperture; a few specimens show one to three spiral lirae within the outer lip. An extremely common species in the Reklaw deposits, outnumbering the other *Pyramidella* spp. by at least 10:1.

Type information.—Holotype: ANSP 1567. Type locality: Claiborne Bluff, Monroe County, Alabama. Range lower Claibornian in Texas to upper Claibornian in Alabama. Figured Reklaw specimen: PRI 30529, from locality 20.

Material examined.—197 specimens, the largest: 7.0 mm length, 1.7 mm width.

Pyramidella (Cossmannica) filamentosa, new species

Plate 23, figures 7–8

Description.—Shell small, to ten whorls. Protoconch heterostrophic of one and a half whorls, 50% immersed in the succeeding whorl. Spire conical, whorls straight-sided to feebly excavated medially, and carinated above the impressed suture. Surface polished with fine lines of growth and ultramicroscopic spiral lines. Body whorl angulated medially, smoothly rounded basally. Outer lip sharp and where fractured showing a few lirae internally. Columella with one strong fold with a weaker one below at a more acute angle ending at a labial swelling.

Remarks.—Where most of the labial area has been broken, a microscopic umbilicus may be visible, but since no specimens with a complete labrum show that feature, the species has been assigned to subgenus *Cossmannica,* instead of the umbilicated subgenus *Ulfa.* The characters place this species close to *Pyramidella (Ulfa) chavani* Palmer, 1937, from the McBean and Gosport Sand formations, although that is a stouter species which is umbilicated and has stronger spiral striations on the base.

Etymology.—The specific name *filamentosa* (Latin, filament), refers to the microscopic spiral lines on the surface.

Type information.—Holotype: PRI 30530; paratypes: PRI 30531–30534. Type locality: locality 20.

Material examined.—27 specimens, the largest: 4.4 mm length, 1.1 mm width.

Pyramidella (Cossmannica) tundrae, new species

Plate 23, figures 5–6

Description.—Shell small, whorls 12, spire cyrtoconoid and usually somewhat bent near the posterior end. Protoconch of one and one-quarter to one and one-half heterostrophic whorls, 50% immersed in the succeeding whorl. Adult whorls straight-sided to excavated, polished, and with a narrow shoulder giving the whorls a stepped appearance. Aperture ovate, outer lip thin and with a few lirae within, columella with one large fold and a small one anteriorly. Inner lip strongly reflected, umbilicus minute to closed.

Remarks.—This is a very variable species, particularly with regard to the size of the shoulder and the subsutural angulation. Some specimens have an almost smooth profile while others are prominently stepped. A few specimens have the whorls stepped to such a degree as to give the appearance of a medial furrow. A characteristic feature is the rounded and bent spire. *Pyramidella (Longchaeus) larvata* Conrad, 1833b, a similar species from the Gosport Sand, has a larger spiral angle, straight to convex whorls, and more prominently impressed sutures. Even though the lectotype of *P. (L.) larvata* is uniplicate, Palmer (1937, p. 72) places the species in *Longchaeus,* because other specimens do show three columellar plicae, although two of them very weakly. One specimen shows the second fold weakly duplex but as the remaining characters are the same the species is left in *Cossmannica.*

Etymology.—Referring to the smooth, featureless character of the whorls.

Type information.—Holotype: PRI 30405; paratypes: PRI 30439–30412. Type locality locality 20.

Material examined.—95 specimens, the largest (the holotype) 5.2 mm length.

Pyramidella (Cossmannica) tundrae zigguratum, new subspecies

Plate 23, figures 9–10

Description.—Shell very small, whorls six, cyrtoconoid, solid. Protoconch largely immersed, nucleus not visible. Adult whorls smooth or with ultra-microscopic spiral striae, shouldered and moderately excavated medially. Body whorl moderately expanded basally, below that gently carinate. Aperture subquadrate; columella sturdy, straight with two folds, the upper one strong, the lower much weaker and at a greater angle to the axis.

Remarks.—The strongly cyrtoconoid profile and stepped concave whorls seem unique to the Pyramidellidae. The most closely related species is *P. (C.) tundrae* s.s., from which it differs by an accentuation of the concave sides of the whorls, more prominently stepped whorls and the carinate body whorl. Some specimens of *P. (C.) tundrae* do approach these but no intermediate examples connecting them were found.

Etymology.—Noting the resemblance to a ziggurat with the stepped sides.

Type information.—Holotype: PRI 30479. Type locality: locality 4.

Material examined.—Four specimens, the largest: 1.2 mm length.

Genus **ODOSTOMIA** Fleming, 1817, p. 76

Type species.—Turbo plicatus Montague, 1803, by subsequent designation (Gray, 1847a, p. 159). Recent off the British Isles.

Diagnosis.—Shell small to very small, high, conical. Protoconch low, considerably immersed. Whorls usually smooth, occasionally with spiral sculpture. Aperture not holostomatous; labrum sometimes lirate; columella concave with one strong fold. Sometimes umbilicated.

Remarks.—The genus is known from the Upper Cretaceous to Recent.

Subgenus **DOLIELLA** Monterosato, 1880, p. 73

Type species.—Odostomia (Doliella) nitens Jeffreys, 1870, by subsequent designation (Dall and Bartsch, 1909, p. 15). Recent in the Mediterranean off Sicily.

Diagnosis.—Postnuclear whorls sculptured similarly throughout, no varices present, shell polished with no axial sculpture, spiral sculpture consisting of a more or less conspicuous spiral ridge.

Remarks.—The subgenus ranges from the Eocene to Recent.

Odostomia (Doliella?) ova, new species

Plate 23, figures 11–12

Description.—Whorls five and a half, nucleus globose, the tip immersed. Whorls straight-sided with a slightly swollen subsutural ridge. Suture impressed. Body whorl basally carinated; below the carina sloping in a straight line to the anterior part of the aperture. One strong columellar fold, outer lip usually lirate within but not extending to the edge; umbilicus small and partly covered by the inner lip.

Remarks.—This species seems to be unique in the Claibornian. The closest described species is perhaps *Odostomia (Evalea) melanella* (Lea, 1833), from the McBean and Gosport Sand formations, with which it shares smooth outer whorls, microscopic striations, and lirations within the outer lip that die out before the edge. The Reklaw species is much smaller, more elongate, more prominently carinate at the base of the body whorl, and has a swollen subsutural ridge.

Etymology.—Noting the ovate apertural shape.

Type information.—Holotype: PRI 30536; paratype: PRI 30537. Type locality: locality 4.

Material examined.—25 specimens, the largest: 2.5 mm length.

Odostomia spp.

Remarks.—At least two other species of *Odostomia* appear to be present, all very small in size and may be juvenile; the largest is about 1 mm in length. The most common species seems assignable to subgenus *Heida* Dall and Bartsch, 1904; it shows a continuous peristome, an almost channeled base and no apparent sculpture. The only Tertiary species showing any similarity is *Odostomia (Odostomia) aff. angularis* Dall and Bartsch, 1904.

Material examined.—13 specimens, the largest: 1 mm length.

Subfamily **TURBONILLINAE** Bronn, 1849

Genus **TURBONILLA** Risso, 1826, p. 224

Type species.—Turbonilla plicatula Risso, 1826, by subsequent designation (Dall and Bartsch, 1903, p. 269). Pliocene of Italy.

Revised diagnosis.—Shell very elevated, with prominent longitudinal ribs, sometimes also with spiral ornamentation; suture strongly impressed; aperture rounded-rhombohedral; columella with a single low plication which is either not visible, or is only just visible within the aperture. Protoconch heterostrophic, considerably elevated.

Remarks.—The genus is known from the Eocene to Recent.

Turbonilla cf. **neglecta** Meyer
Plate 23, figure 18

Turbonilla neglecta Meyer, 1886, p. 69, pl. 1, figs. 4, 4a; de Gregorio, 1890, p. 159, pl. 15, figs. 31, 32 copy Meyer; Cossmann, 1893, p. 24; 1912, p. 279; Palmer, 1937, p. 81, pl. 8, figs. 4, 11, copies Meyer; Palmer and Brann, 1966, p. 973; Knight, Hodgkinson, Knight, Reid, Lindveit, Lindveit, and Offeman, 1977, p. 33.

Original description.–"Subulate; whorls flattened, closely covered with broad and distinct transverse ribs, ending rather abruptly on the last whorl and leaving the base smooth; aperture subquadrilangular, longer than broad; inner lip twisted, thus forming an obtuse fold at some distance from the sharp outer lip; crenulate within by a few distant elevated spiral lines." (Meyer, 1886, p. 69)

Remarks.—Several broken specimens that can provisionally be assigned to *T. neglecta* were obtained. One specimen shows the inner lip extended tongue-like to the left of the columella, a feature only poorly displayed by Meyer's figure of the species. At least three separate axially costate *Turbonilla* species exist in the Clabornian and would need a thorough revision to place them correctly. Unfortunately Meyer's holotype is lost, *fide* Palmer (1937, p. 81).

Type information.—Syntypes: USNM 638821, 638822. Figured Reklaw specimen: PRI 30540, from locality 4.

Material examined.—Two specimens, the largest: 1.7 mm length.

Subgenus **PTYCHEULIMELLA** Sacco, 1892, p. 59

Type species.—*Tornatella pyramidata* Deshayes, 1833a, by original designation. Recent in the eastern Mediterranean.

Original diagnosis.—"Testa turrito-pyramidata. Anfractus planulati, ultimus saepe plus minusque subangulatus. Apertura ovato-quadrangula vel rhomboidis. Columella supernae, depressae, transverse uniplicata." (Sacco, 1892, p. 59) Translation: Shell turrited; whorls smooth, the last whorl often more or less angulated; aperture ovate-quadrilateral or rhomboidal; columella excavated, one oblique fold.

Remarks.—Dall and Bartsch (1904), in their synopsis of the genus, also noted the presence of at most, microscopic spiral sculpture, the absence of a basal keel and the presence of feeble axial ribs on the early whorls. Wenz (1939) places *Ptycheulimella* under *Eulimella,* Gray, 1847a. The genus is known from the Eocene to Recent.

Turbonilla (Ptycheulimella) meta, new species
Plate 23, figures 13–15

Description.—Shell small, whorls 13. Protoconch of two and a half smooth whorls, strongly heterostrophic with the angle of inclination at ca. 120° and projecting well outside the profile of the spire. First three adult whorls with numerous, faint, backward curving riblets, more prominent posteriorly. Whorls polished and on post-ribbed stage straight-sided and excavated below the deeply impressed suture. The surface shows faint lines of growth that are occasionally developed into obsolete swellings. Aperture trapezoidal, labrum smooth, columella with one strong fold at the base; umbilical depression present.

Remarks.—This species has affinities with *Turbonilla (Ptycheulimella) clinensis* (Aldrich, 1921) from the Lower Eocene of Gregg's Landing, Alabama, but that is an altogether stouter species with a rounded spire and the columellar fold placed nearer the base.

Etymology.—The specific name *meta* (Latin, target), refers to the nuclear whorls jutting outside the axial profile of the later whorls.

Type information.—Holotype: PRI 30541; paratypes: PRI 30542–30545. Type locality: locality 20.

Material examined.—65 specimens, the largest: 4.5 mm length, 1.0 mm width.

Subgenus **PYRGISCUS** Philippi, 1841, p. 50

Type species.—*Melania rufa* Philippi, 1836, by original designation. Recent, Gulf of Gascoyne in the Mediterranean.

Diagnosis.—Shell without a basal keel; spiral sculpture always present, whose strength is stronger than microscopic in character. Whorls not strongly shouldered.

Remarks.—The subgenus ranges from the Eocene to Recent.

Turbonilla (Pyrgiscus) sp.
Plate 23, figures 16–17

Remarks.—One small fragment was obtained of a turrited shell that is similar to *Turbonilla (Pyrgiscus) agrestis* (Aldrich, 1911), from the Lower Eocene Hatchetigbee Formation. The present specimen has one spiral line per whorl less than *T. (P.) agrestis* and there is a tendency for the lines to become nodular where they cross over the axial folds.

Type information.—Figured specimen: PRI 30480, from locality 20.

Material examined.—One specimen, 2.0 mm length.

Order **NOTASPIDEA** Fisher, 1883, p. 571

Superfamily **UMBRACULOIDEA** Odhner, 1939, p. 13

Family **UMBRACULIDAE** Dall, 1889c, p. 88

Genus **UMBRACULUM** Schumacher, 1817, p. 177

Type species.—*Umbrella chinensis* Martini, 1784 (= *Patella sinica* Gmelin, 1791 by monotypy). Recent, seas off China.

Diagnosis.—Shell moderate to large, ovate; surface with concentric growth lines and sometimes also radial lines; protoconch small, almost central, dextral; interior with radial lines from the apex to the concentric muscle scar.

Remarks.—In the fossil state the closely similar genus *Tylodina* Rafinesque, 1814, can be distinguished by its sinistrally coiled nucleus. *Umbraculum* is known from the Eocene to Recent.

Umbraculum tomaculum, new species
Plate 23, figures 25–26

Description.—Shell medium-sized, ovate in outline, low-conical in profile. Protoconch anterior to the longitudinal midsection, dextral, with a bulbous nucleus followed by about one-eighth of a turn that is set asymmetrically on the adult shell at an angle of about 22° to the longitudinal axis. Apex central, sculpture of numerous fine, radial, flattened lines and comarginal growth resting stages; the entire ornament very subdued. Inner surface porcellaneous and smooth with a few faint radial undulations. Muscle scar very faint except posteriorly, obsolescent towards the anterior (broken) end.

Remarks.—Palmer and Brann (1966, p. 1010) list three *Umbraculum* species from the Lower Eocene Hatchetigbee, Lisbon, and Upper Eocene Moody's Branch formations. The genus is probably much more common than indicated but the flat circular shell does not favour its preservation. I have specimens from the the Weches and Cook Mountain formations, which are all fairly similar and also are similar to the common Jackson *Umbraculum planulatum* (Conrad, 1854). These species are almost entirely concentrically sculptured, have a well-defined entire muscle scar, and when preserved show a closely coiled protoconch. The Reklaw species is higher, primarily radially sculptured on the dorsal surface, and on the holotype shows a somewhat elongated "sausage like" protoconch lying on the surface with the apical end apparently dextrally coiled. A possibly related species is *Eosinica elevata* (Aldrich, 1903), from the Lower Eocene Sabinian Stage; Zilch (1959, p. 60) places *Eosinica* doubtfully in the Umbraculidae (questionably in the Patellidae). *Eosinica elevata* is moderately high, primarily radially sculptured, and has a smooth interior and a crenulated margin. *Eosinica* also occurs in the Cook Mountain Formation, Erickson (1982) described an *Acmaea* (?) sp. nov. 1, which almost certainly belongs to this genus although the protoconch is missing; *Acmaea* has an inflated, non-spiral protoconch.

Etymology.—Noting the protoconch shape.

Type information.—Holotype: PRI 33075; paratype: PRI 33077. Type locality: locality 21.

Material examined.—Two specimens, the holotype 12.7 mm actual length, 13.5 mm width. Estimating from previous growth lines, the unbroken length would be almost 18 mm.

Class **CEPHALOPODA** Cuvier, 1797, p. 378

Subclass **COLEOIDEA** Bather, 1888, p. 302

Order **SEPIIDA** Zittel, 1895, p. 445

Suborder **MYOPSINA** d'Orbigny, 1839, p. 220

Family **SEPIIDAE** Kerferstein, 1866, p. 1441

Subfamily **BELOSAEPIINAE** Naef, 1921, p. 536

Genus **BELOSAEPIA** Voltz, 1830, p. 23

Type species.—*Beloptera sepioidea* Blainville, 1825, by original designation. Eocene of France.

Diagnosis.—Phragmocone bent, semiconical, laterally flattened; exterior dorsally coarsely granular; interior smooth with transverse laminae, an elliptical ventral siphuncle, terminating in a solid beak bent in the dorsal direction; dorsal base of beak expanded into an elevated callus, ventral base of beak connected to a semicircular plate expanded posteriorly over part of the rostrum, and anteriorly connecting to the lateral margins of the shell.

Remarks.—The genus ranges from the Paleocene to the Upper Eocene and is cosmopolitan in distribution.

Belosaepia penna, new species
Plate 23, figures 27–28

Description.—Shell rounded, beak bent sharply forward almost at a 90° angle, lip lost. Ventral plate thin, wide and winglike, bent upward at the ends and with longitudinal ridges in groups of five or six on the upper surface and terminating in a crenate edge; below with shorter and more prominent ridges, every fifth or sixth one larger. Dorsal surface under the tip roughly rugose, and with large pimples; the remainder of the dorsal surface finely rugose. Cavity with worn chamber outlines, initially round, then greatly expanding lateroventrally; anterior upper inside surface flattened with the upper and lower margins thickened into lateral ridges. Outer surface of the phragmocone chambers finely ridged with wrinkled radial and spiral lines giving a rasp-like appearance.

Remarks.—This species is distinct from all other American species of *Belosaepia* in several features, including the wrinkled surface of the ventral plate, the sharp bend in the rostrum, and the smoothly rounded profile below; other species are also more flattened ventrally. One unique specimen appears to show the remnants of four inner chambers, and thus shows the character of the rugose outer surface; its inner surface is apparently smooth. The shape of the cavity with the impressed lines, expanding strongly in the ventral direction, over the inner edge of the ventral plate and laterally, indicates that the phragmocone must have initially expanded in a ventral direction past the plate and a little in the direction of the beak, and then back towards the rostrum. One species from the Cuisian of the Paris Basin appears related, *Belosaepia tricarinata* (Watelet, 1851); this species also has a strongly bent beak and coarsely ribbed ventral plate; it can be distinguished by the strongly crescent-shaped ventral plate, larger size and stronger ornamentation on the dorsal side of the rostrum.

Etymology.—The specific name *penna* (Latin, wing), notes the thin, wide character of the ventral plate.

Type information.—Holotype: PRI 33130. Type locality: locality 20.

Material examined.—75 specimens, the largest: 10 mm from the center to the tip of the ventral plate, 13 mm height from the middle of the ventral plate to the base.

Subclass **NAUTILODEA** Agassiz, 1847, p. 246

Order **NAUTILIDAE** Agassiz, 1847, p. 246

Superfamily **NAUTILOIDEA** de Blainville, 1825

Family **HERCOGLOSSIDAE** Spath, 1927, p. 22

Genus **ANGULITHES** Montfort, 1808, p. 7

Type species.—*Nautilus triangulithes* Montfort, 1802, by original designation. Upper Cretaceous of France.

Diagnosis.—"Conch very involute, generally compressed, whorl sides slightly convex, strongly convergent, venter narrowly rounded to angular. Suture moderately sinuous with a narrowly rounded ventral saddle, a broad lateral lobe, a narrow, rounded saddle, and a small lobe on the umbilical shoulder. Siphuncle small and located near the dorsum." (Kummel, 1956, p. 454–455)

Remarks.—The genus has been reported from England, India, Senegal, Somalia, the only New World occurrence being from the Reklaw.

Angulithes elliotti (Stenzel, 1940)

Plate 23, figures 30–31

Deltoidnautilus elliotti Stenzel, 1940, p. 759–764, pl. 38, figs. 1–6, pl. 39, figs. 1, 2, text figs. 123(2), 124(2).

Angulithes elliotti (Stenzel, 1940). Kummel 1956, p. 35–456; Palmer and Brann, 1965, p. 372–373.

Description.—Shell involute, large and thick. Cross section of early whorls truncate-triangular, becoming gradually high-triangular with a sharply rounded venter. Ornamentation absent except for growth lines and very indistinct wavy raised spirals best developed near the umbilicus. Lateral zones very long and gently curved or flat, converging towards the venter at an angle of 48°. Septa closely spaced and convex; siphuncle slightly less than one-quarter of the distance from the dorsum, siphuncle collar tubular and long. Ventral saddle the largest, and prominently rounded-triangular, lateral lobe broad and gently curved; lateral saddle relatively deep and narrow lying a short distance from the umbilical shoulder, a medium sized lobe on the narrow perforate umbilicus; dorsum with a broad lobe.

Remarks.—One additional specimen found in a sandy lens in Ridge Creek.

Type information.—Holotype: TBEG 20901. Type locality: locality 6.

Family **ATURIIDAE** Hyatt, 1894[17]

Genus **ATURIA** Bronn, 1838, p. 1122

Type species.—*Nautilus aturi* Basterot, 1825, by subsequent designation (Hermannsen, 1846, p. 90). Miocene of southwestern France.

Diagnosis.—Shell involute, compressed, cross section initially triangular-oval, becoming subrectangular by the last whorl. Early whorls widest at or near the umbilical shoulder, becoming widest in the vicinity of the lateral zones. Umbilical shoulder not well defined, umbilical area one-ninth to one-eighth of whorl height. Lateral zones gently curved, in the last whorl nearly parallel medially, converging at an angle of 29° to 32° from the middle to the broadly evenly rounded venter. Septa convex, siphon narrow and funicular. Sutures slightly wavy across the venter, a small, narrow saddle at the corner of the base of the rapidly tapering and pinched lateral lobe; lateral saddle evenly rounded.

Remarks.—The genus is known from the Paleocene to the Miocene.

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[17] Kummel *in* Moore (1964) cites Chapman (1857) as author of the family name Aturiidae. Extensive search has failed to locate this reference. Aturinae Hyatt, 1894, cited in Kummel (1956), is used *nomen transl.* Aturiidae herein.

Aturia turneri, Stenzel, 1940
Plate 23, figures 29–30

Aturia (Brazaturia) turneri Stenzel 1940, pp. 732, 766, 770, pl. 41, figs. 1–6, text-figs. 125 (2), 126 (7).
Aturia turneri Stenzel. Stenzel (1942), Cephalopoda cards Nos. 27a, 27b, figs. 1–5, text-figs. 125 (2), 126 (7); Miller, 1947, p. 108, pl. 72, figs. 1–5; Kummel, 1956, pp. 343, 468; Palmer and Brann, 1965, p. 375.

Description.—Shell involute, compressed, and flat lenticular in shape; cross section of body whorl subrectangular. Early whorls widest at or near the umbilical shoulder, but last preserved whorl widest in the region from the vicinity of the umbilical shoulder to the middle of the lateral zones. Umbilical shoulder and area as in the genus. Lateral zones are only gently curved in the earlier whorls and converge at an angle of about 29° ; lateral zones of the last preserved whorl gently curved and nearly parallel from the vicinity of the umbilical shoulder to their middle, but converging at an angle of 32° from their middle on towards the venter; venter broadly and evenly rounded. Sutures slightly wavy across venter; a small narrow saddle at the ventral corner of the base of the lateral lobe; lateral lobes rapidly tapering and pinched in at the point which is recurved dorsally; lateral saddle broadly arched.

Remarks.—Several small fragments and two larger ones discovered, most extremely pressure distorted. One partial clay mold shows the characteristic suture pattern well and another large portion of the body whorl has the lateral zones converging at an angle of about 30° and also shows a deep and well-rounded hyponomic sinus. Small nautiloid cephalopods are not at all rare in the unctuous dark clays in the Reklaw, particularly at Joe Taylor Branch, but they are almost always small, thin-shelled, very fragile, and tend to be destroyed at the moment of discovery. Another small species of nautiloid, which is very globose, and possibly a *Eutrephorceras* sp., is not uncommon at Joe Taylor Branch, but no specimen complete enough for description has been recovered.

Type information.—Holotype: TBEG 20905. Type locality: locality 6.

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PLATES

EXPLANATION OF PLATE 1

Figure Page

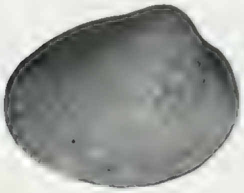
1–4. ***Nucular cochlear,*** new species 22
Locality 24
1,2. External and internal views of a left valve, the holotype, ×5.5 (PRI 30260).
3,4. External and internal views of a right valve, a paratype, ×5.5 (PRI 30261).

5–8. ***Litorhadia milamensis,*** new species 24
Locality 20.
5,6. Internal and external views of a right valve, the holotype, ×8, (PRI 30265).
7,8. External and internal views of a left valve, a paratype, ×8, (PRI 30266).

9–12. ***Nuculana (Sacella) demissa,*** new species 23
Locality 7.
9,10. External and internal views of a left valve, the holotype, ×11 (PRI 33070). Specimen broken and repaired.
11,12. External and internal views of a right valve, a paratype, ×11 (PRI 33071).

13–16. ***Nuculana (Jupiteria) turgeo,*** new species 22
Locality 20.
13,14. External and internal views of a right valve, the holotype, ×12 (PRI 30262).
15,16. External and internal views of a left valve, a paratype, ×12 (PRI 30263).

17. ***Litorhadia*** sp. 25
Locality 12.
17. A left valve, ×5.8 (PRI 30552).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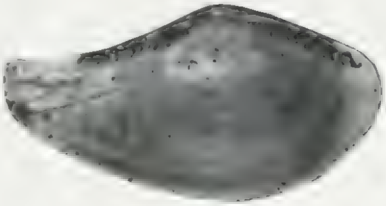
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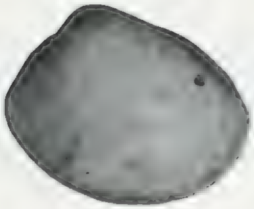
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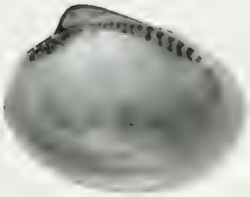
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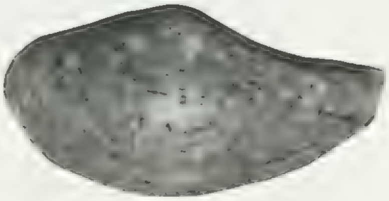
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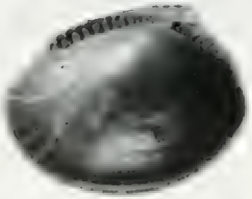
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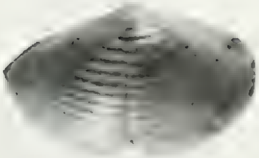
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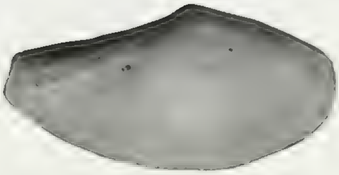
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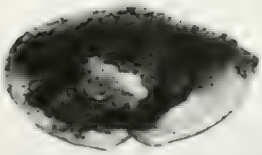
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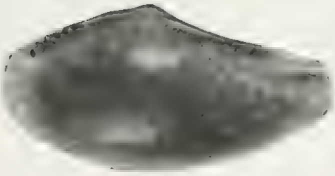
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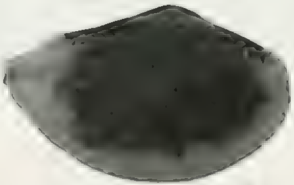
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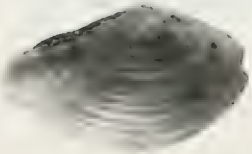
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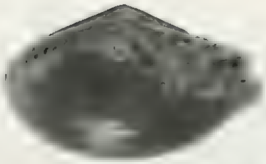
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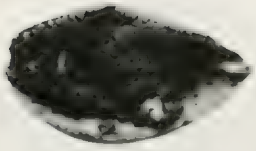
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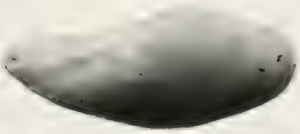
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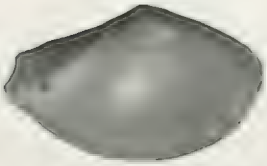
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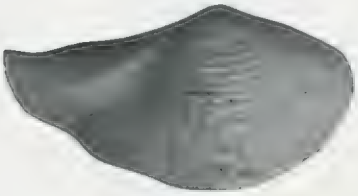
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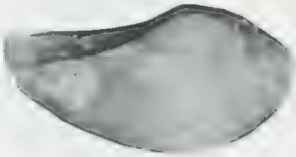
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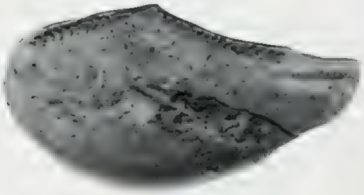
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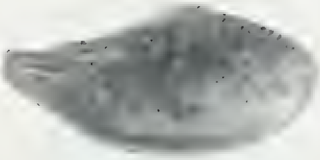
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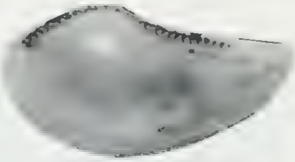
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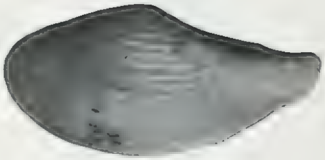
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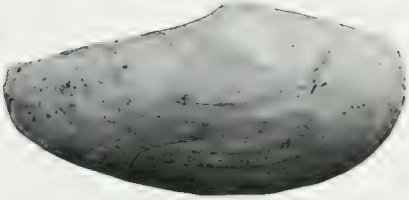
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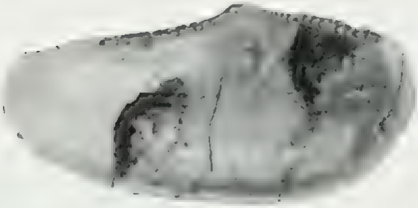
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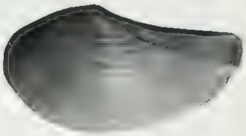
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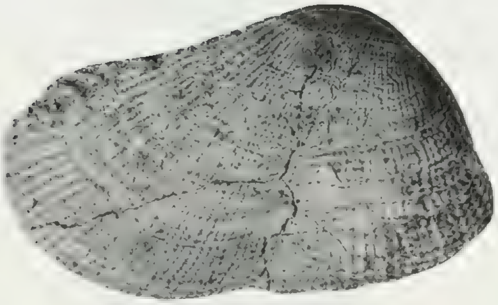
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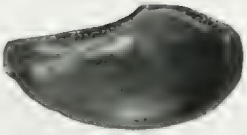
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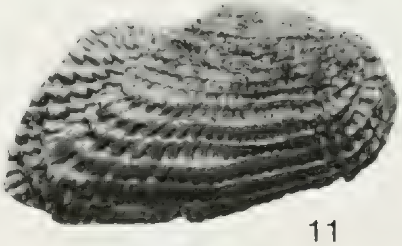
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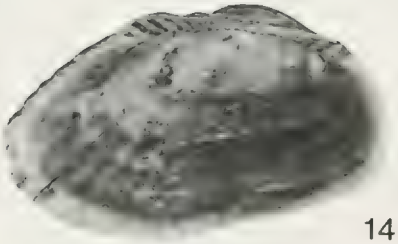
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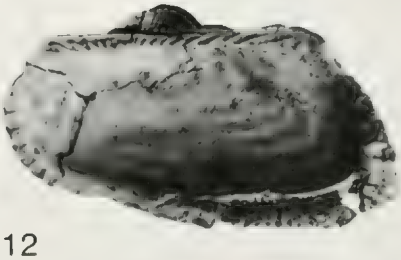
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EXPLANATION OF PLATE 2

Figure Page

1–4. ***Litorhadia undulata*,** new species 24
Locality 20.
1,2. External and internal views of a left valve, the holotype, ×5.75 (PRI 30268).
3,4. External and internal views of a right valve, a paratype, ×5.75 (PRI 30269).

5–8. ***Litorhadia valdefragilis*,** new species 24
Locality 5.
5,6. External and internal views of a left valve, the holotype, ×10 (PRI 30270).
7,8. External and internal views of a right valve, a paratype, ×10 (PRI 30296).

9–10. ***Orthoyoldia psammotaea vivianensis*** (Harris) 25
Locality 20.
9. External view of a right valve, ×3.5 (PRI 30271). Valve attached to matrix.
10. Internal view of a left valve, ×3.5.

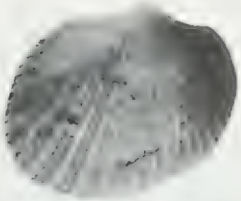
11–12. ***Barbatia (Acar) salebrosus*,** new species. 26
Locality 20.
11,12. External and internal views of a right valve, the holotype, ×3.8 (PRI 30272).

13–14. ***Barbatia (Cucullaearca) reklawensis*,** new species 26
Locality 20.
13. External view of a right valve, the holotype, ×1.5 (PRI 30273). Valve attached to matrix.
14. Internal view of a juvenile left valve, a paratype, ×6.3 (PRI 30274).

15. ***Barbatia*** sp. 27
Locality 8.
15. External view of a right valve, ×4.5, cemented to a hard indurated sandstone (PRI 30305).

EXPLANATION OF PLATE 3

Figure		Page
1–4.	***Bathyarca claibornica,*** new species	27
	Locality 20.	
	1,2. External and internal views of a right valve, the holotype, ×11 (PRI 30275).	
	3,4. Internal and external views of a left valve, a paratype, ×11 (PRI 30276).	
5,6.	***Glycymeris*** sp.	28
	Locality 20.	
	5,6. External and internal views of a left valve, ×5.5 (30280 PRI).	
7–10.	***Pachecoa concentrica,*** new species	28
	Locality 20.	
	7,8. External and internal views of a left valve, the holotype, ×8.3 (PRI 30277).	
	9,10. External and internal view of a right valve, a paratype, ×8.3 (PRI 30278).	
11,12.	***Gregariella ridgei,*** new species	29
	Locality 4.	
	11,12. Internal and external views of a right valve, the holotype, ×9 (PRI 33072).	
13,14.	***Mytilus (Crenomytilus)*** sp.	29
	Locality 4.	
	11,12. Internal and external views of a double valve, ×5 (PRI 30281).	
15,16.	***Atrina***? sp.	30
	Locality 20.	
	15. External view of the beak area of one valve, ×2, attached to matrix (PRI 30548).	
	16. External view of a fairly complete specimen, ×1, the edge of the shell deliniated (PRI 30549).	



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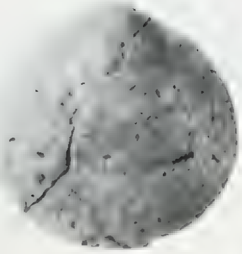

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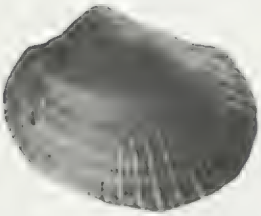

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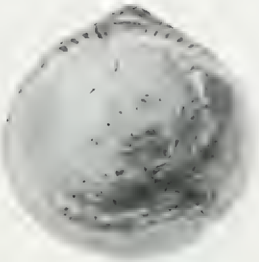

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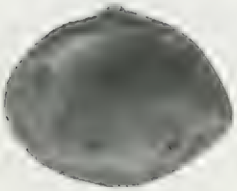

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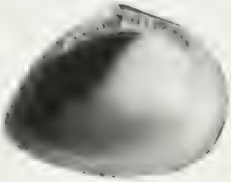

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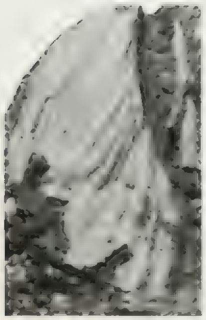

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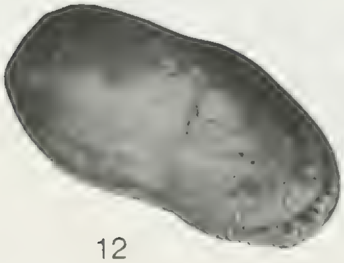

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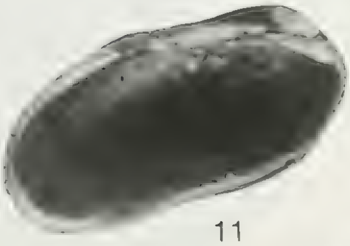

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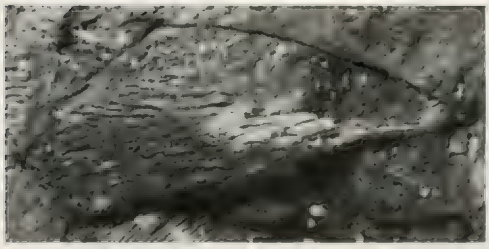

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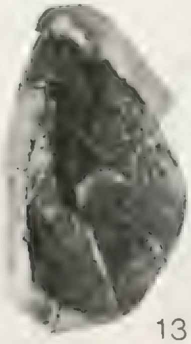

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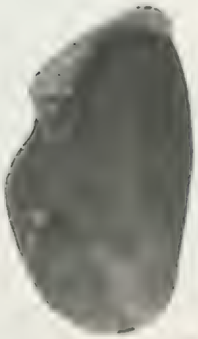

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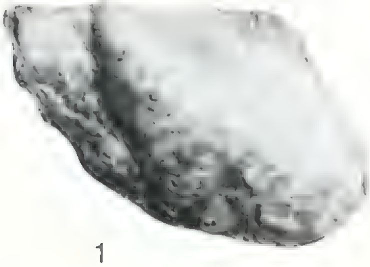

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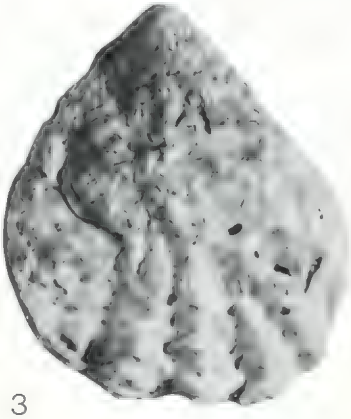

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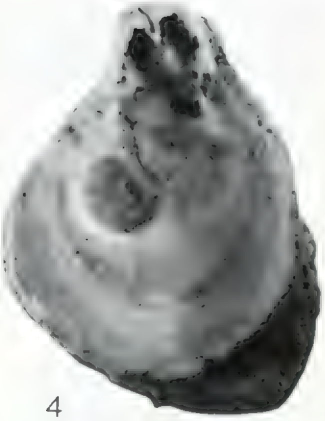

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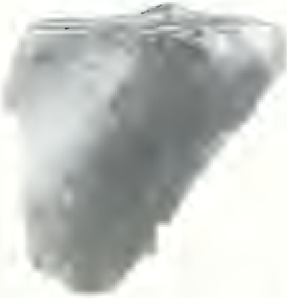

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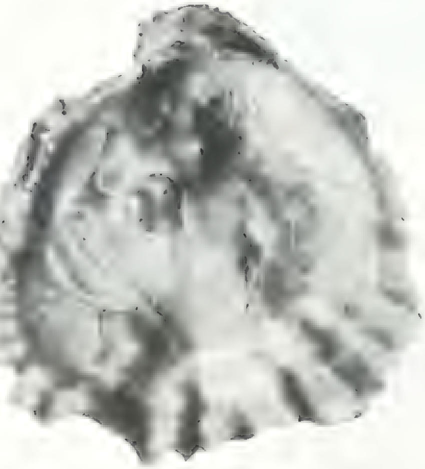

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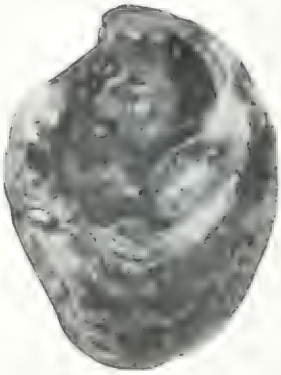

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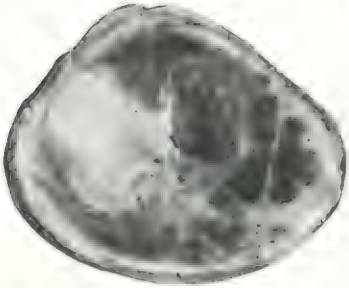

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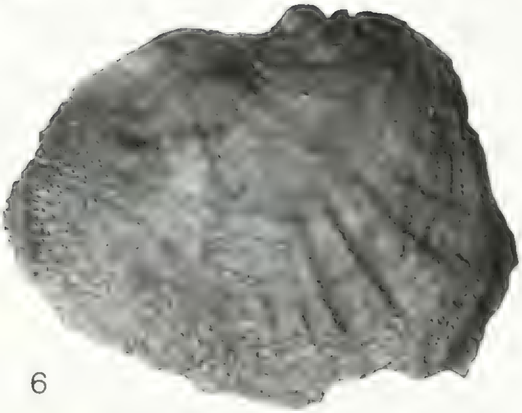

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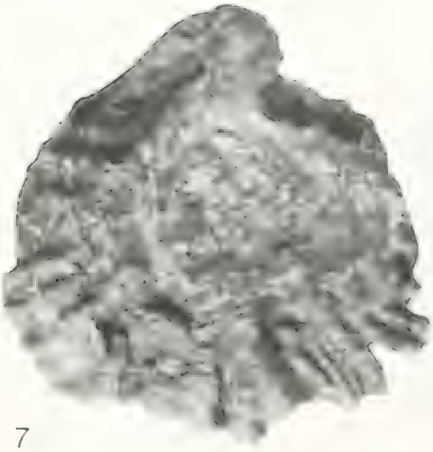

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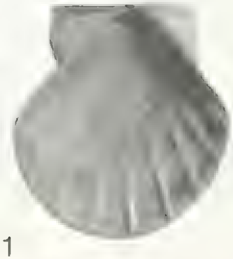

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EXPLANATION OF PLATE 4

Figure Page

1,2. ***Pteria petropolitana*** Stenzel and Twining 30

Locality 7.

1. External view of a left valve, ×1, attached to matrix (PRI 30282).
2. Internal view of of a left valve, ×4.3, illustrating the hinge dentition (PRI 30283).

3,4. ***Plicatula pustula*,** new species 31

Locality 20.

3,4. External and internal views of a right valve, the holotype, ×2.4 (PRI 30286).

5–9. ***Hyotissa offemanae*,** new species 32

Locality 25.

5,7. Internal and external views of a left valve, the holotype, ×1.6 (PRI 30554).

6. External view of a right valve, a paratype, ×1.5, showing the internal vesicular structure of the shell (PRI 30555).

8. External view of a juvenile *Hyotissa* sp., ×3.5, referred doubtfully to this species (PRI 30556). Locality 2.

9. Internal view of another juvenile *Hyotissa* sp., ×3.5, referred doubtfully to this species (PRI 33120). Locality 2.

10,11. ***Amusium (Propeamusium) zinguli*,** new species 31

Locality 7.

10,11. External and internal views of a left valve, the holotype, ×6.5 (PRI 30284).

EXPLANATION OF PLATE 5

Figure Page

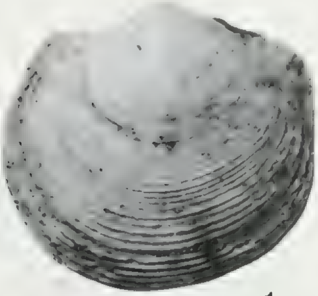
1–4. ***Anodontia (Eophysema) reklawensis,*** new species 33
Locality 20.
1,2. External and internal views of a left valve, the holotype, ×6.5 (PRI 30289).
3,4. External and internal views of a right valve, a paratype, ×6.5 (PRI 30290).

5–6. ***Chama taylorensis,*** new species 34
Locality 20.
5,6. External and internal views of a left valve, the holotype, ×4 (PRI 30294).

7–10. ***Clabornicardia coloradonis*** subsp. 35
Locality 11.
7,8. External and internal views of a left valve, ×2.5 (TMM 8483).
9,10. External and internal views of a right valve, ×2.5 (TMM 8482).

11–12. ***Claibornicardia linguinodifera milamensis*** new subspecies 35
Locality 20.
11,12. External and internal views of a right valve, ×3 (PRI 30298).

13. ***Eosolen shirleyi*** new species 36
Locality 14.
13. External view of a right valve, the holotype, ×2.5, specimen attached to matrix (PRI 30301).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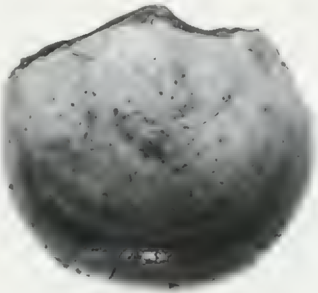
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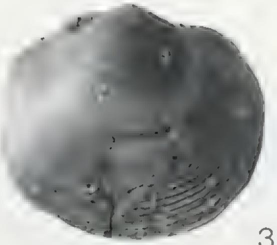
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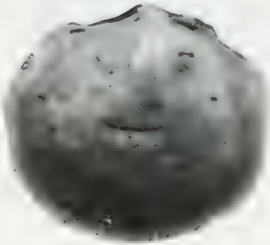
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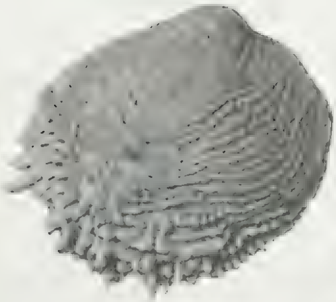
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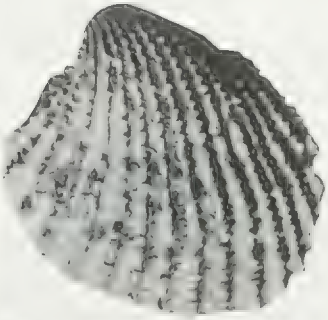
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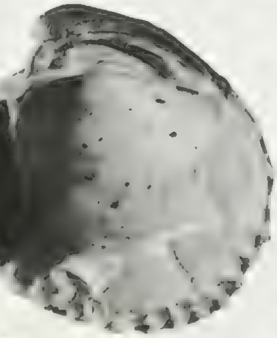
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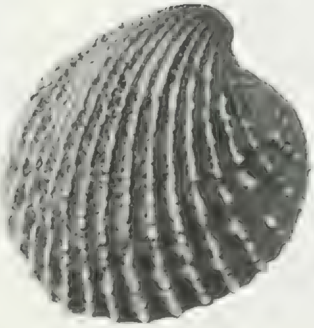
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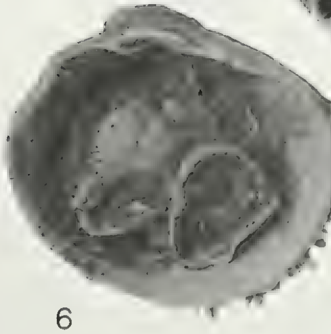
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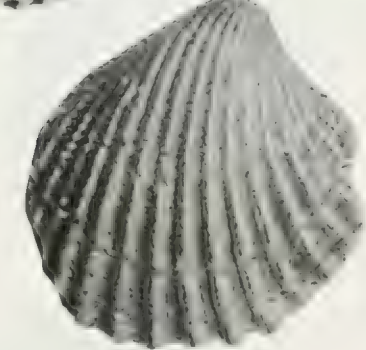
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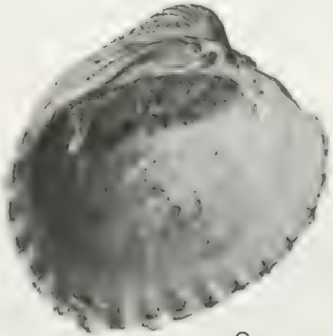
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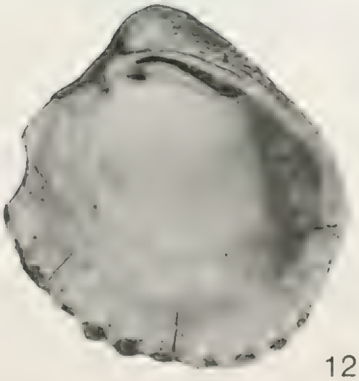
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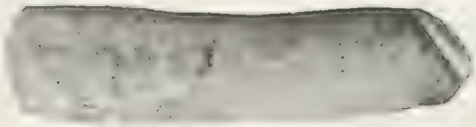
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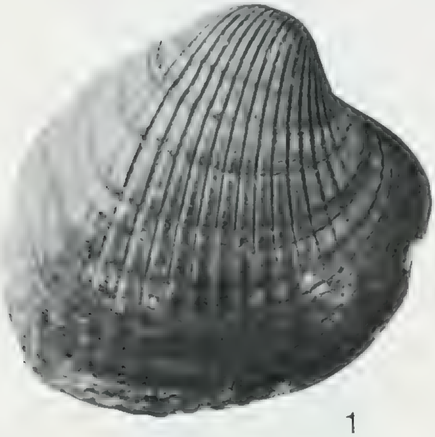
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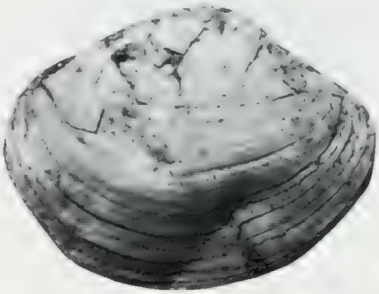
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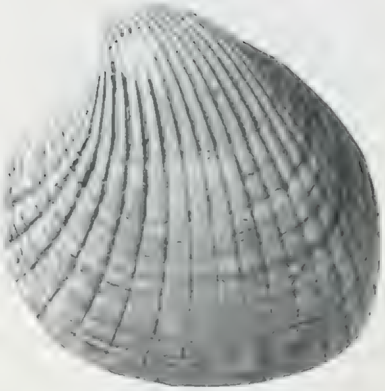
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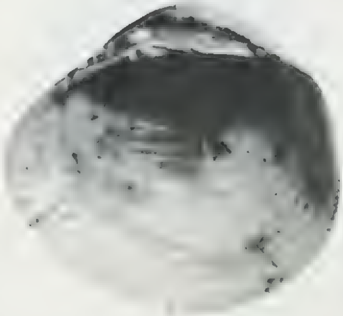
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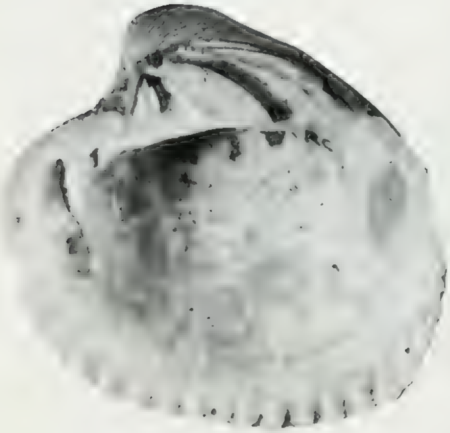
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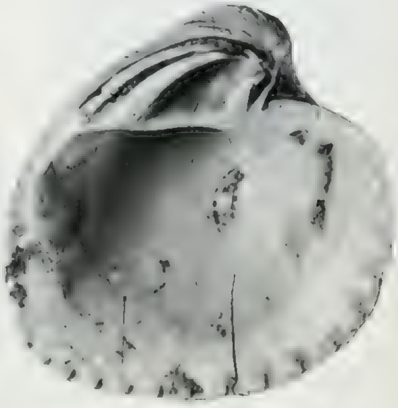
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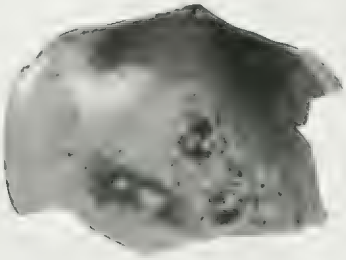
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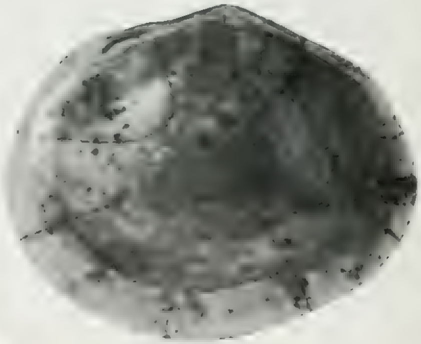
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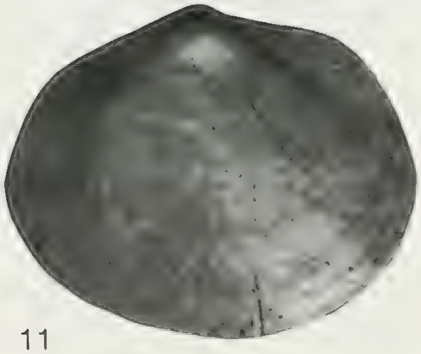
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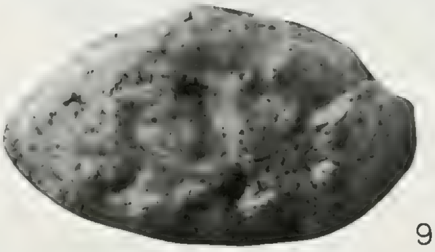
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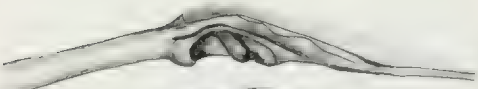
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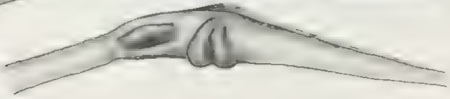
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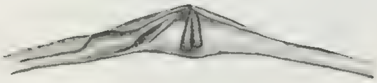
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EXPLANATION OF PLATE 6

Figure | Page
1–4. ***Venericor densata reklawensis,*** new subspecies 34
Locality 20.
1,2. External and internal views of a right valve, the holotype, ×1 (PRI 30296).
3,4. External and internal views of a left valve, a paratype, ×1 (PRI 30297).
5–8. ***Tenuimactra hodgkinsoni,*** new species 36
Locality 4.
5,6. External and internal views of a right valve, the holotype, ×7.5 (PRI 33074).
7. Sketch of hinge area of right valve (PRI 33074).
8. Sketch of reconstructed hinge area of a left valve (PRI 30443).
9–10. ***Tellina (Eurytellina?) milamensis,*** new species 37
Locality 20.
9. External view of a left valve, the holotype, ×4, attached to matrix and somewhat distorted in extraction (PRI 30302).
10. Sketch of a reconstructed hinge area of a right valve, a paratype, ×30 (PRI 33121).
11–13. ***Arcopagia (Arcopagia) trumani*** (Harris) 38
Locality 20.
11,13. External and internal views of a right valve, ×6 (PRI 33076).
12. Internal view of a fragment of a left valve, ×6 (PRI 33122).

EXPLANATION OF PLATE 7

Figure — Page

1–2. ***Pitar (Calpitaria) turneri***, new species 39
Locality 4.
1,2. External and internal views of a right valve, the holotype, ×1.8 (PRI 33086). Specimen reconstructed from fragments

3–6. ***Pitar (Calpitaria?)*** sp. 40
Locality 4.
3,4. External and internal views of a juvenile left valve, ×33 (PRI 33133).
5,6. External and internal views of a juvenile right valve, ×33 (PRI 33132).

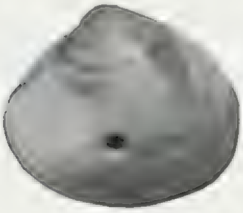
7–10. ***Lutetia*** cf. ***texana*** Harris 38
Locality 4.
7,8. External and internal views of a left valve, a paratype, ×55 (PRI 33082).
9,10. External and internal views of a right valve, the holotype, ×55 (PRI 33081).

11–12. ***Alveinus*** cf. *minutus* Conrad 38
Locality 4.
11,12. External and internal views of a right valve, ×18 (PRI 33085).

13. ***Pitar (Katherinella?)*** sp. A 40
Locality 20.
14. External view of a left valve, ×3.5 (33088 PRI).

14. ***Pitar (Katherinella?)*** sp. B 40
Locality 11.
13. External view of a left valve, ×2.3. Specimen attached to a hard indurated sandstone. Texas Memorial Museum specimen (TMM 84819).

15–18. ***Caryocorbula marquezensis***, new species 41
Locality 20.
15,16. External and internal views of a right valve, the holotype, ×8 (PRI 30300).
17,18. External and internal views of a left valve, a paratype, ×8 (PRI 30303).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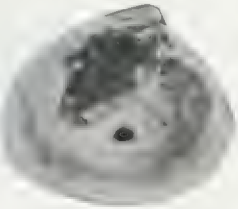
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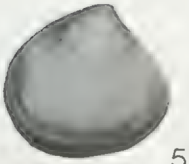
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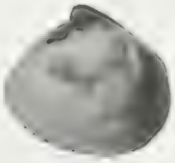
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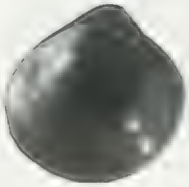
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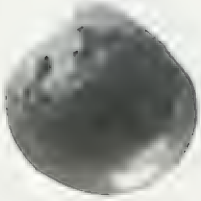
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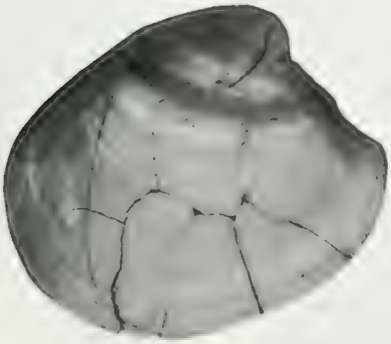
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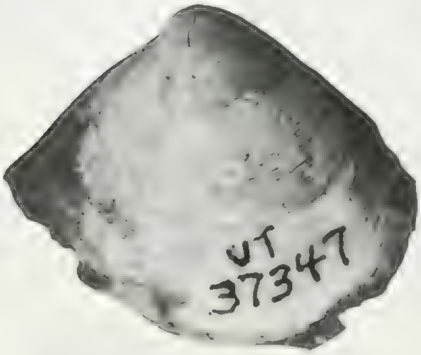

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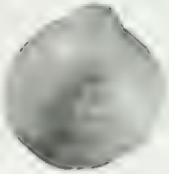
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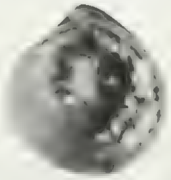
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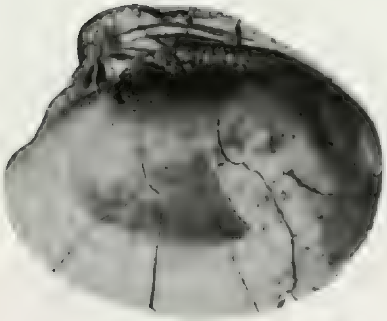
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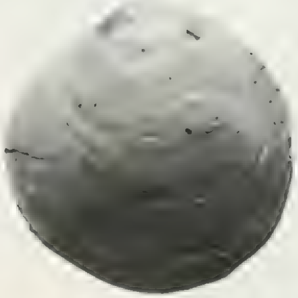
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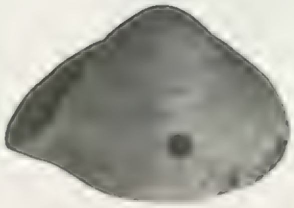
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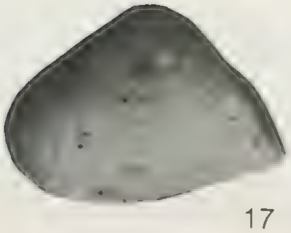
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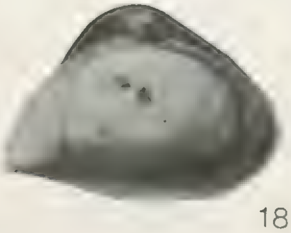
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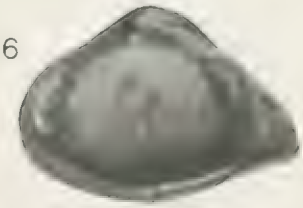

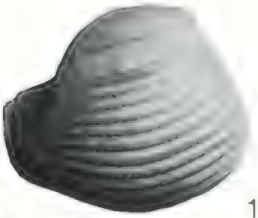
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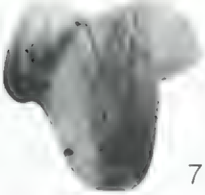
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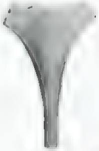
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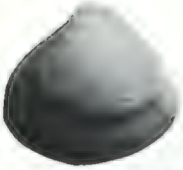
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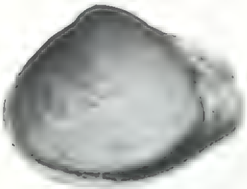
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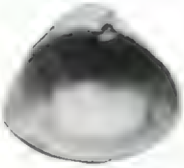
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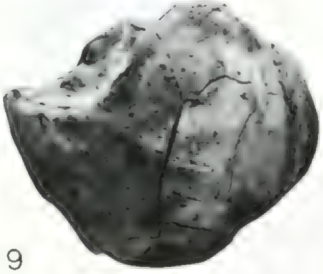
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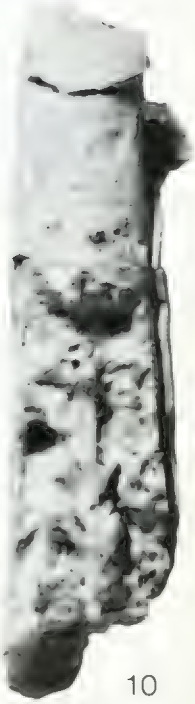
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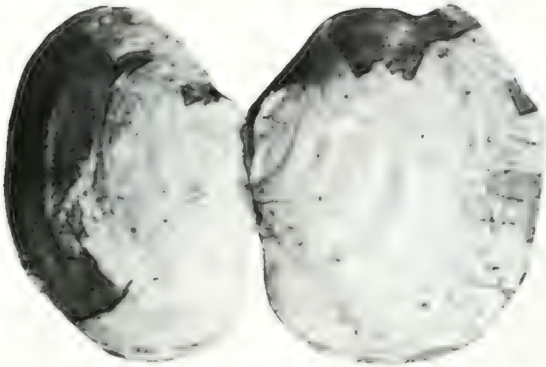
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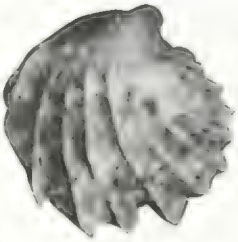
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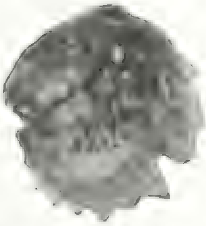
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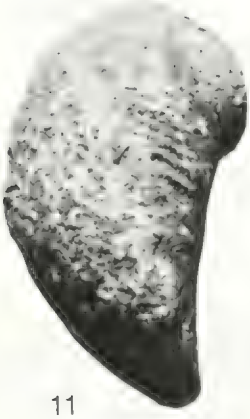
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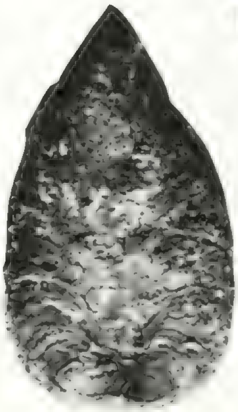
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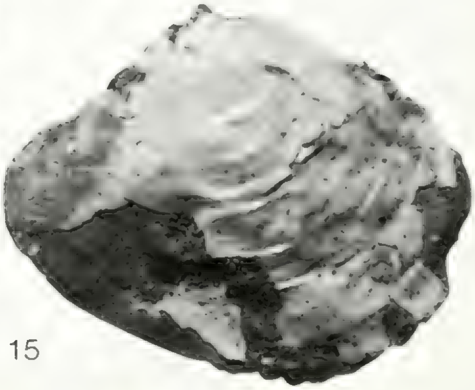
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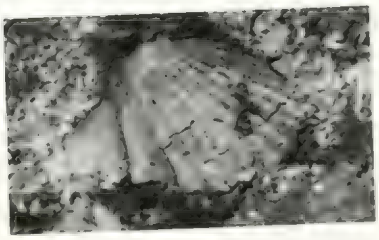
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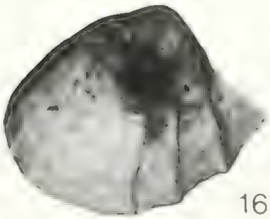
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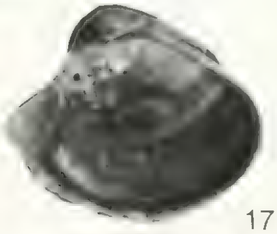
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EXPLANATION OF PLATE 8

Figure Page

1–5. ***Notocorbula marquezensis,*** new species . . . 41
Locality 20.
1,2. External and internal views of a right valve, the holotype, ×8 (PRI 30305).
3,4. External and internal views of a left valve, a paratype, ×8 (PRI 30306).
5. View of a double valve, a paratype, ×8 (PRI 30307).

6. ***Panopea***? sp. . . . 42
Locality 7.
6. External view of a double valve specimen, ×6 (PRI 30487). Specimen attached to block of matrix.

7–10. ***Bankia (Lydrobankia) petalus,*** new species . . . 42
Locality 7.
7. External view of a free juvenile valve, a paratype, ×11 (PRI 33090).
8. View of a free pallet, a paratype, ×15 (PRI 33091).
9. External view of an adult valve, a paratype, ×6 (PRI 33092). Specimen attached to end of tube.
10. External view of tube, split to show pallets in situ, holotype, ×11 (PRI 33125).

11–12. ***Pholadomya*** cf. *leonensis* Stenzel and Twining . . . 43
Locality 4.
11,12. Lateral and umbo views of a double valve "clay mold" specimen, ×2.3 (PRI 33096).

13–14. ***Verticordia (Trigonulina)*** cf. *satex* Gardner . . . 45
Locality 4.
13,14. External and internal views of a right valve, ×21 (PRI 33099).

15. ***Cochlodesma (Cochlodesma) ovalis,*** new species . . . 43
Locality 4.
15. External view of a right valve, the holotype, ×5 (PRI 33097).

16–17. ***Cardiomya fredsmithi,*** new species . . . 44
Locality 20.
16,17. External and internal views of a left valve, the holotype, ×13 (PRI 30482).

18. ***Cardiomya*** sp. . . . 44
Locality 7.
18. External view of a right valve, ×7 (PRI 30538). Specimen attached to matrix.

EXPLANATION OF PLATE 9

Figure Page

1. View of a section a very fossiliferous sandy, weakly indurated lens
Locality 20.

2. ***Dentalium (Antalis) palmerae,*** new species 46
Locality 4.
2. View of the holotype, ×2.6 (PRI 30313).

3–5. ***Cadulus (?) bisissura,*** new species 46
Locality 4.
3. Side view of the holotype, ×12 (PRI 30314).
4,5. Views of the anterior and posterior cross-sections of the holotype, ×22.

6. ***Cadulus (Polyschides)*** cf. ***subcoarcuatus*** (Gabb) 47
Locality 7.
6. Side view of a specimen from locality 2 (PRI 33121).

7–8. ***Episiphon gracilis,*** new species 45
Locality 4.
7. Side view of the holotype, ×4 (PRI 30310).
8. View of the posterior cross-section of the holotype.

9–10. ***Littorina (Prosthenodon) cofasciata,*** new species 50
Locality 4.
9,10. Front and rear views of the holotype, ×9 (PRI 33100).

11–12. ***Cyclostremiscus axacuus*** (Conrad) 51
Locality 4.
11,12. Top and basal views of a Reklaw specimen, ×7.7 (PRI 33102).

13–14. ***Tubiola gracilis,*** new species 52
Locality 20.
13,14. Top and basal views of the holotype, ×10.5 (PRI 30316).

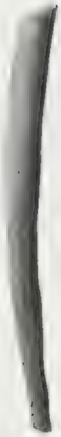
15–16. ***Solariorbis discoides,*** new species 53
Locality 20.
15–16. Top and basal views of the holotype, ×15 (PRI 30317).

17–18. ***Solariorbis conicus,*** new species 53
Locality 7.
17,18. Top and basal views of the holotype, ×16 (PRI 30320).

19–20. ***Solariorbis? parsnaticoides,*** new species 53
Locality 14.
19,20. Top and basal views of the holotype, ×14 (PRI 30323).

21–22. ***Teinostoma*** cf. ***texanum*** Palmer 54
Locality 20.
21,22. Top and basal views of a Reklaw specimen, ×54 (PRI 33103).

23–24. ***Theodoxus domicilium,*** new species 47
Locality 20.
23,24. Front and rear views of the holotype, ×6.6 (PRI 30328).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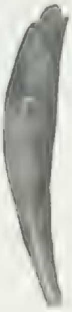
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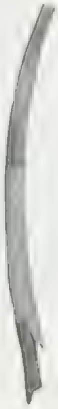
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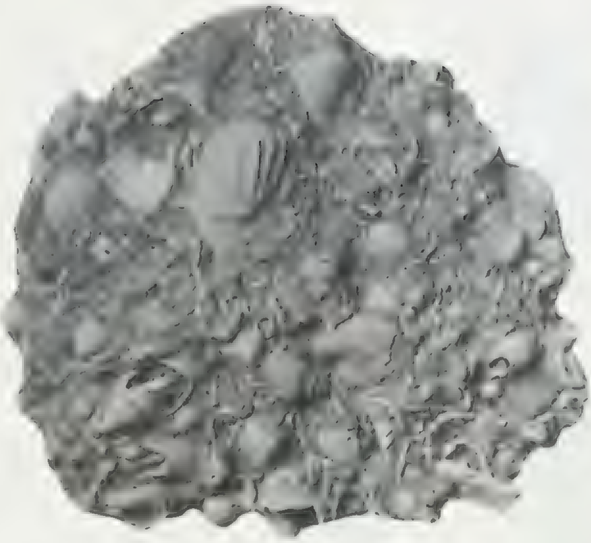
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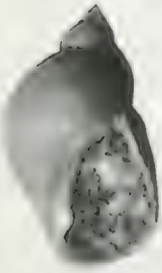
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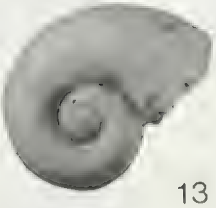
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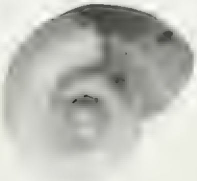
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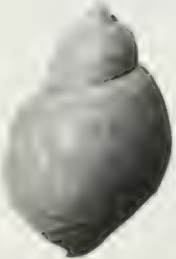
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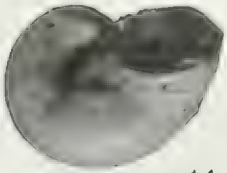
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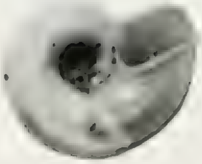
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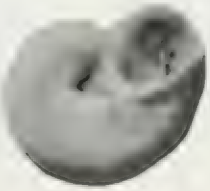
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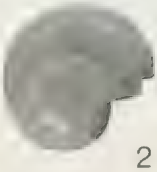
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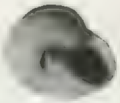
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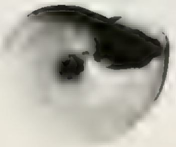
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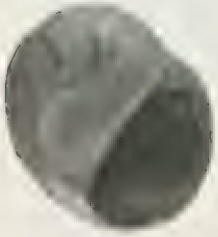
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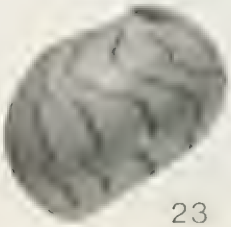
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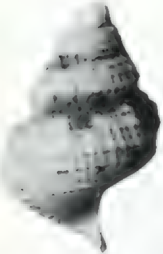
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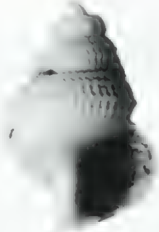
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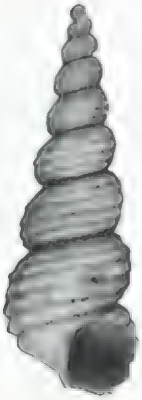
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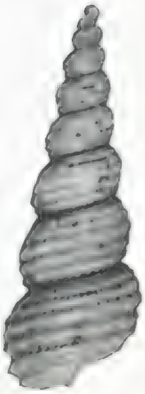
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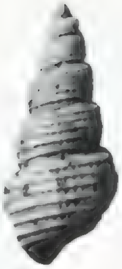
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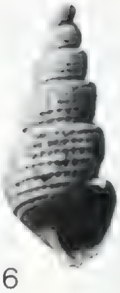
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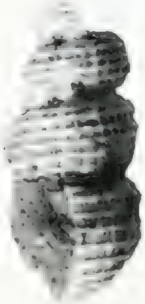
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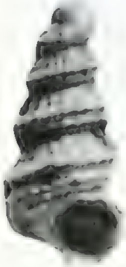
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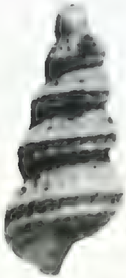
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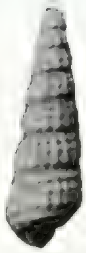
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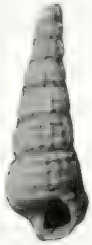
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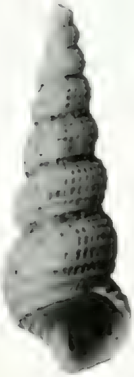
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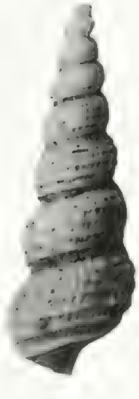
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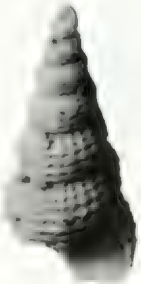
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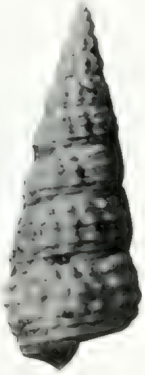
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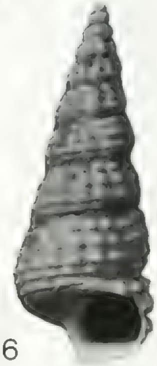
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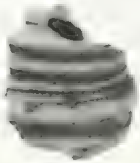
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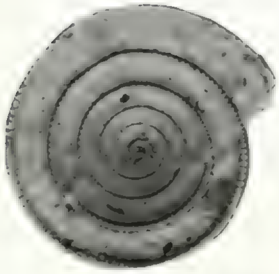
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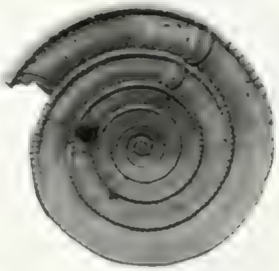
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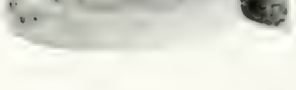
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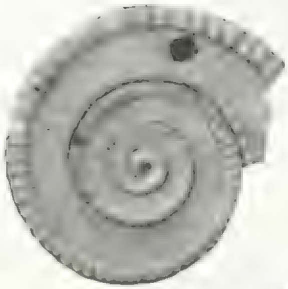
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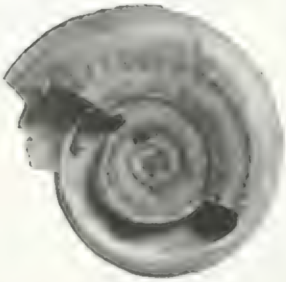
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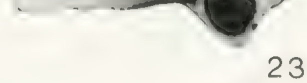
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Explanation of Plate 10

Figure		Page
1–2.	***Gegania antiquata texana*** (Palmer)	106
	Locality 4.	
	1,2. Rear and front views of a Reklaw specimen, ×7.5 (PRI 30550).	
3–4.	***Mathilda (Mathilda)*** cf. *retisculpta aldrichi* Palmer	106
	Locality 4.	
	3,4. Front and rear views of a specimen complet with nucleus, ×8 (PRI 33104).	
5–7.	***Mathilda (Echinimathilda?) cribraea,*** new species	107
	Locality 4.	
	5,6. Rear and front views of the holotype, ×8.5 (PRI 30329).	
	7. Side view of a fragment of a larger specimen, a paratype, ×8.5 (PRI 30330).	
8–9.	***Mathilda (Fimbriatella) iugum,*** new species	107
	Locality 4.	
	8,9. Front and rear views of the holotype, ×15 (PRI 33080).	
10–11.	***Bittium ridgei,*** new species	49
	Locality 4.	
	10,11. Rear and fron views of the holotype, ×11 (PRI 30334).	
12–14.	***Glyptozaria americana,*** new species	108
	Locality 4.	
	12,13. Front and rear views of the holotype, ×7.3 (PRI 33078).	
	14. View of the paratype showing the protoconch, ×9 (PRI 33079).	
15–16.	***Bittium tresquatrum,*** new species	49
	Locality 4.	
	15,16. Rear and front views of the holotype, ×5 (PRI 30331).	
17.	***Mathilda (Mathilda)*** cf. *claibornensis* Aldrich	106
	Locality 20.	
	17. Rear view of a fragment, ×9 (PRI 30415).	
18–20.	***Pseudomalaxis reklawensis,*** new species	108
	Locality 20.	
	18,19,20. Top, basal and apertural views of the holotype, ×4.3 (PRI 30336).	
21–23.	***Pseudomalaxis? acuta,*** new species	109
	Locality 20.	
	21,22,23. Top, basal and apertural views of the holotype, ×8.1 (PRI 30291).	

EXPLANATION OF PLATE 11

Figure Page

1–2. ***Architectonica (Stellaxis) reklawensis,*** new species 109
Locality 20.
1. Top view of the holotype, ×2 (PRI 30339).
2. Cross-section of a paratype, ×2.2 (PRI 30340).

3–5. ***Architectonica (Patulaxis?) fimbriaea,*** new species 110
Locality 20.
3,4. Top and basal views of the holotype, ×2.7 (30341 PRI).
5. Side view of the holotype, ×1.6.

6–8. ***Architectonica (Granosolarium) aldrichi caterva,*** new subspecies 110
Locality 20.
6,7,8. Top, basal and apertural views of the holotype, ×6 (PRI 30338).

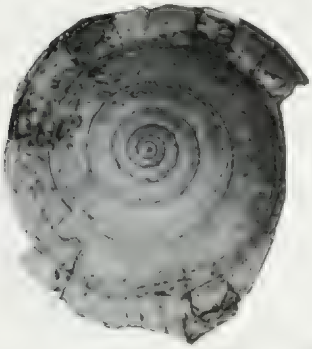
9–10. ***Architectonica (Granosolarium) geminicostata*** new species 111
Locality 20.
9,10. Top and basal views of the holotype, ×2.4 (PRI 30342).

11–12. ***Trimalaxis ora,*** new species 111
Locality 4.
11,12. Top and basal views of the holotype, ×12.5 (30344).

13–14. ***Turritella turneri*** Plummer 49
Locality 2.
13. Front view of a typical specimen, ×4 (PRI 33122).
14. Rear view of a specimen with more pronounced beading, ×4 (PRI 33123).

15. ***Mesalia*** sp. 50
Locality 10.
15. Front view of a specimen from the Texas Memorial Museum, ×3 (UT 19346).

16,17. ***Serpulorbis multiclavus*** new species 55
Locality 4.
16. Views of the holotype, a portion of a tube, ×4.25 (PRI 30345).
17. View of a paratype, a portion of a tube, ×4.25 (PRI 30346.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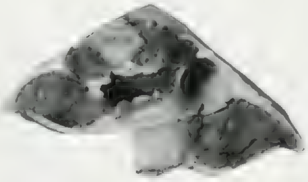
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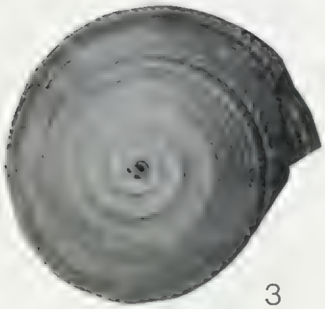
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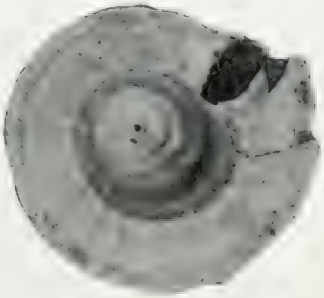
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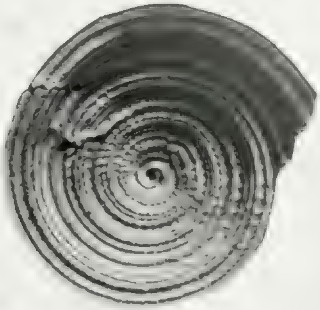
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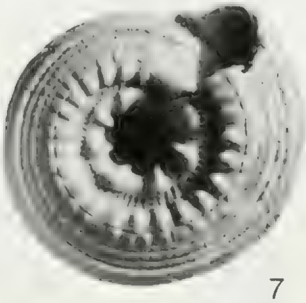
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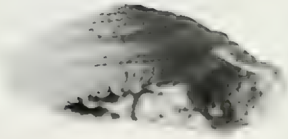
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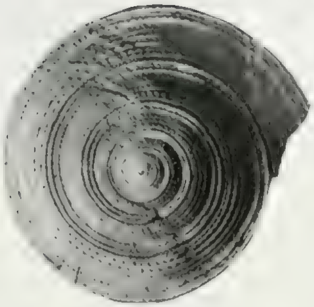
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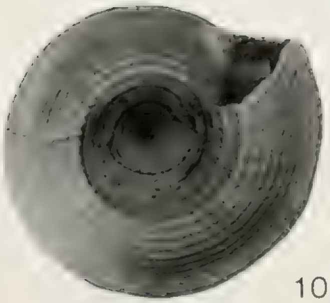
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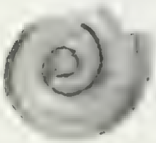
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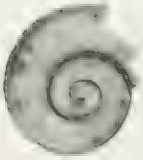
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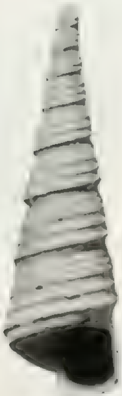
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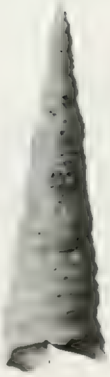
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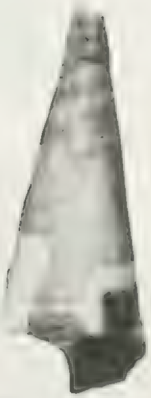
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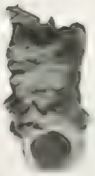
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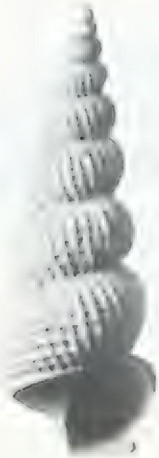
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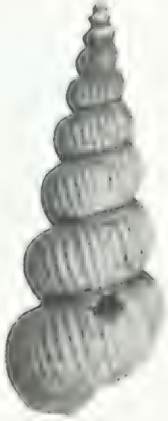
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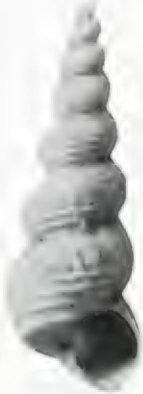
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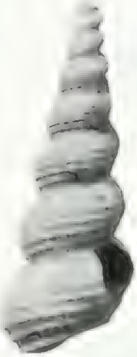
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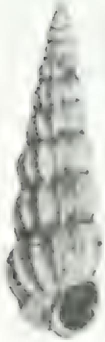
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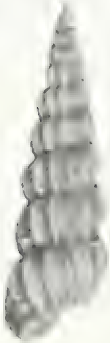
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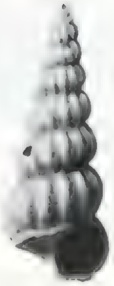
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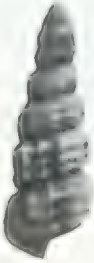
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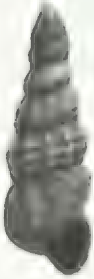
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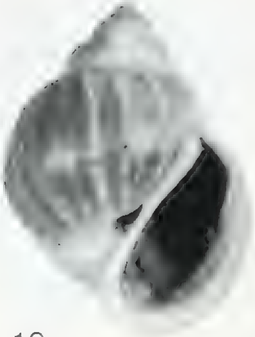
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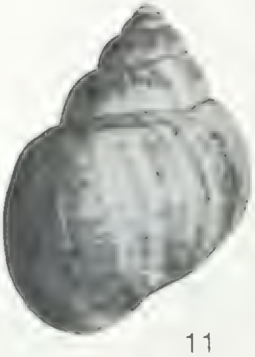
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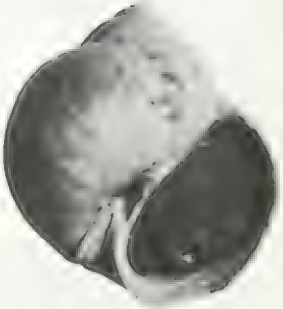
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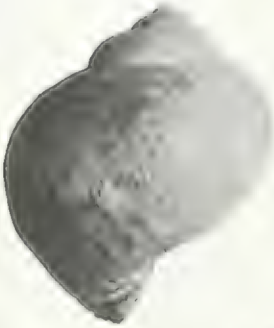
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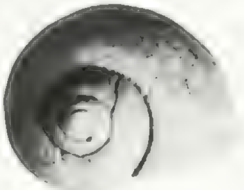
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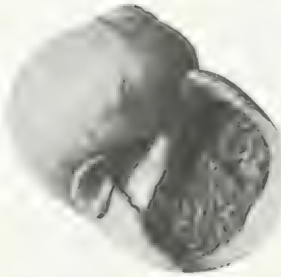
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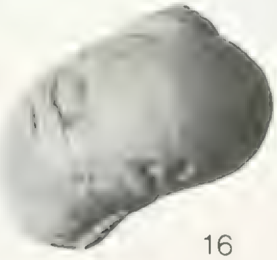
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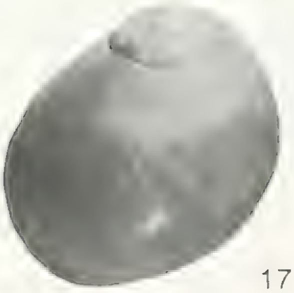
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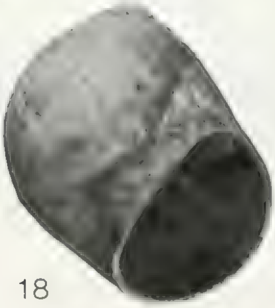
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EXPLANATION OF PLATE 12

Figure . . . Page
1–2. ***Amaea (Scalina) macula,*** new species . . . 64
Locality 20.
1,2. Front and rear views of the holotype, ×5.4 (30350 PRI).
3–4. ***Amaea (Foratiscala) texana,*** new species . . . 65
Locality 7.
3,4. Front and rear views of the holotype, ×5.2 (PRI 30352).
5–6. ***Rugatiscala cooperi,*** new species . . . 65
Locality 4.
6,7. Front and rear views of the holotype, ×8.8 (PRI 30353).
7. ***Rugatiscala***? sp. . . . 66
Locality 20.
7. Front view of the figured specimen, ×8.8 (PRI 33124).
8–9. ***Cerithiopsis (Cerithiopsina?)*** sp. . . . 63
Locality 4.
8,9. Front and rear views of the specimen, ×7 (PRI 30378).
10–11. ***Amaurellina plummeri,*** new species . . . 57
Locality 10.
10,11. Front and rear views of the holotype, ×6 (TMM 3583).
12–14. ***Natica (Naticarius) brevisulcata,*** new species . . . 57
Locality 20.
12–13. Front and rear views of the holotype, ×4 (PRI 30354).
14. Top view of a paratype showing the short radial sulci, ×4 (30355 PRI).
15–16. ***Natica (Carinacca) moffitti,*** new species . . . 58
Locality 20.
15–16. Front and rear views of the holotype, ×3.6 (PRI 30357).
17–18. ***Polinices (Pliconacca) onustus reklawensis,*** new subspecies . . . 59
Locality 20.
17,18. Front and rear views of the holotype, ×4 (PRI 30360).

EXPLANATION OF PLATE 13

Figure Page

1–2. ***Sinum moveum,*** new species 60
Locality 20.
3,4. Front and oblique rear views of the holotype, ×6.3 (PRI 30367).

3–4. ***Sinum taylori,*** new species 59
Locality 20.
3,4. Front and oblique rear views of the holotype, ×6.3 (PRI 30363).

5–6. ***Cypraeaorbis bulbus,*** new species 56
Locality 21.
5,6. Front and rear views of the holotype, ×2 (PRI 30371).

7–8. ***Phalium (Semicassis) reklawensis*** new species 62
Locality 10.
7,8. Rear and front views of the holotype, ×2.8 (PRI 30373).

9–10. ***Neosimnia scobina,*** new species 56
Locality 4.
9,10. Rear and front view of most of the body whorl, ×4 (PRI 30379). (Specimen broken after description and before photography).

11–14. ***Postalia americana,*** new species 54
Locality 20.
11,12,13. Top, front and basal views of the holotype, ×3.8 (PRI 30369). Specimen damaged by slight compression in the apertural plane.
14. Magnified view of the protoconch and early whorls of the holotype, ×12.

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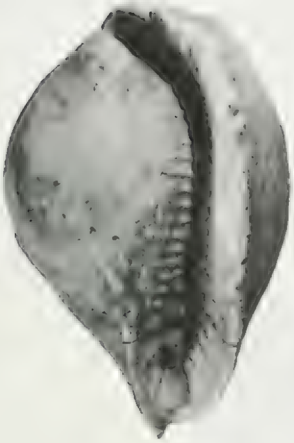
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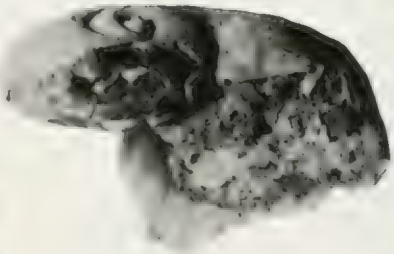
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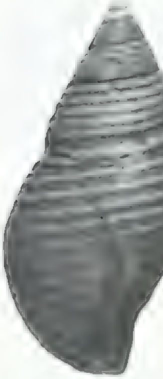
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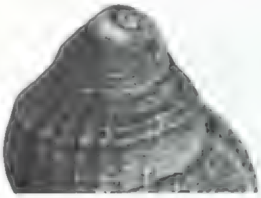
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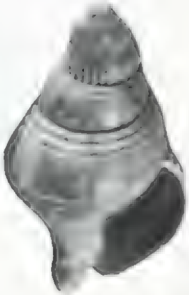
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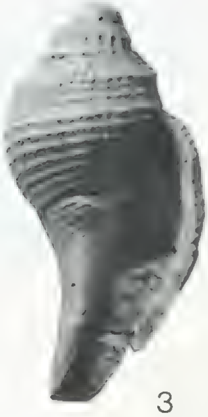
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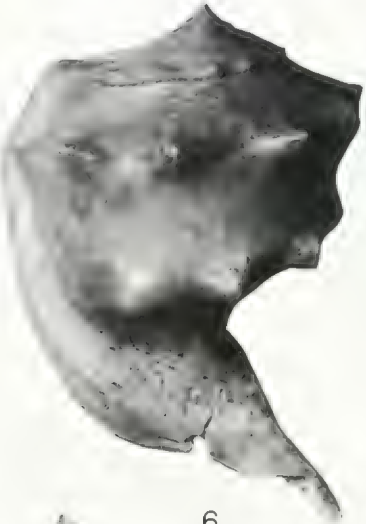
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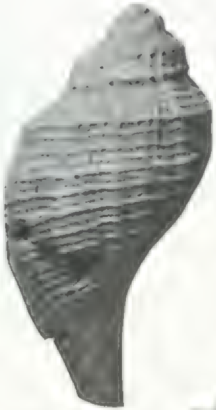
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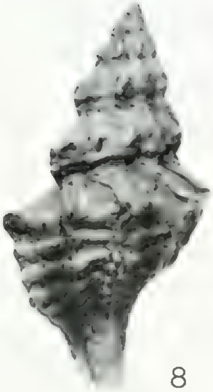
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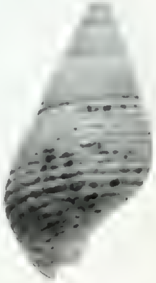
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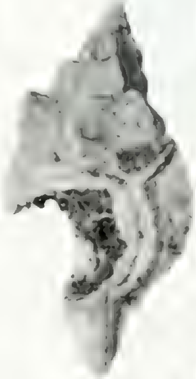
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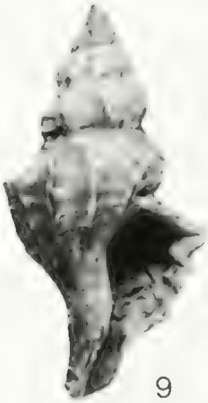
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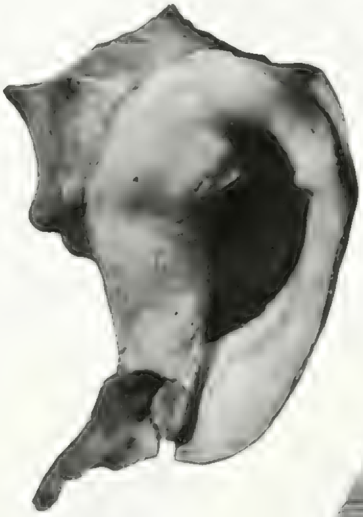
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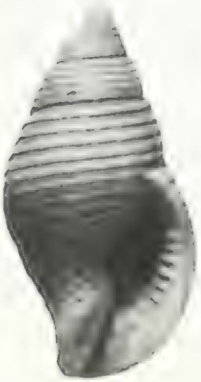
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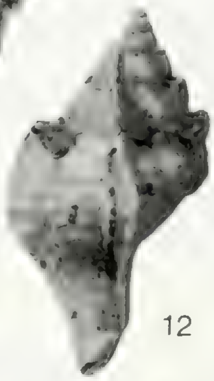
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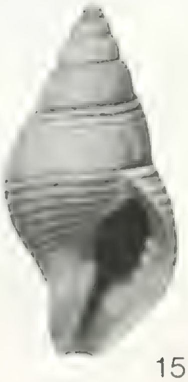
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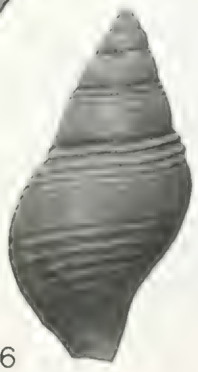
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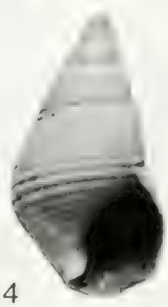
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EXPLANATION OF PLATE 14

Figure		Page
1–2.	***Mitrella (Clinurella) nuttalli lineata*** new subspecies	69
	Locality 20.	
	1,2. Rear and front views of the holotype, ×4.2 (PRI 30385).	
3–5.	***Ficopsis nucleoides*** new species	63
	Locality 20.	
	3,4. Front and rear views of a cotype, ×5.7 (PRI 30374).	
	5. View of the protoconch of a cotype, ×9 PRI 30374).	
6–7.	***Galeodea (Mambrina) turneri*** Gardner	61
	Locality 14.	
	6,7. Rear and front views of an almost complete specimen, ×1 (PRI 33125).	
8–9.	***Hexaplex eoa,*** new species	67
	Locality &.	
	8,9. Rear and front views of the holotype, ×3.75 (PRI 30381).	
10.	**Ectinochilus** sp.	54
	Locality 4.	
	17. View of the early whorls of a Reklaw specimen, ×7 (PRI 30380).	
11–12.	***Pterynotus (Pterynotus)*** cf. *stenzeli* Vokes	68
	Locality 4.	
	11,12. Right side and rear views of a Reklaw specimen, ×5 (PRI 33126).	
13–14.	***Litiopa texana,*** new species	48
	Locality 20.	
	13,14. Rear and front views of the holotype, ×8.2 (PRI 30386).	
15–17.	***Mitrella (Clinurella) nuttalli,*** new species	68
	Locality 20.	
	15,16. Front and rear views of the holotype, ×5.4 (PRI 30383).	
	17. View of a paratype showing the nuclear whorls, ×11 (PRI 30384).	

EXPLANATION OF PLATE 15

Figure Page

1–2. ***Bullia altilis harrisi*** Palmer 74
Locality 20.
1,2. Front and rear views of a Reklaw specimen, ×1.6 (PRI 33127).

3–4. ***Metula elongatoides*,** new species 69
Locality 4.
3,4. Front and rear views of the holotype, ×5 (PRI 30292).

5–6. ***Pseudometula gradus*,** new species 70
Locality 4.
5,6. Front and rear views of the holotype, ×2.5 (30388 PRI).

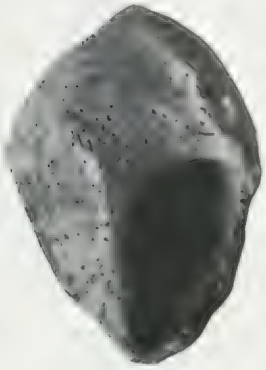
7–8. ***Colwellia bilineata*,** new species 71
Locality 20.
7,8. Front and rear views of the holotype, ×7.5 (PRI 30391).

9–10. ***Colwellia*** sp. 72
Locality 20.
9,10. Front and rear views of the specimen, ×7 (PRI 30438).

11–13. ***Distorsio (Personella) nucleoides*,** new species 71
Locality 21.
11,12. Front and rear views of the holotype, ×7.2 (PRI 30390).
13. Views of the nuclear whorls of a paratype, ×27 (PRI 33109).

14–15. **"*Buccinanops*" *ellipticum reklawensis*,** new subspecies 74
Locality 20.
14,15. Rear and front views of the holotype, ×2 (PRI 30410).

16–17. ***Tritiaria nodosa*,** new species 72
Locality 20.
16,17. Rear and front views of the holotype, ×10 (PRI 30394).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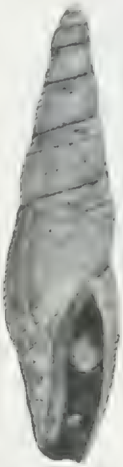
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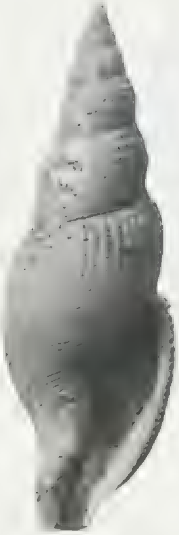
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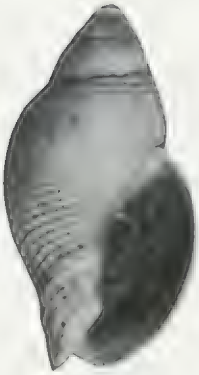
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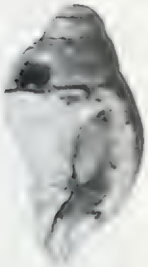
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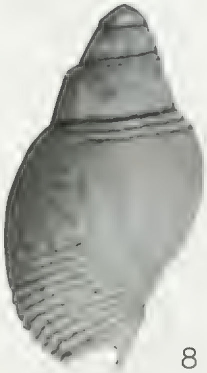
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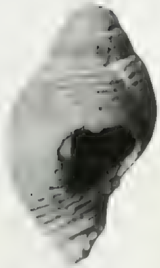
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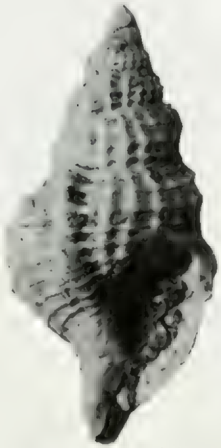
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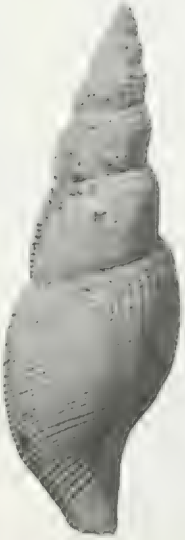
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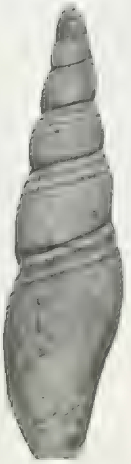
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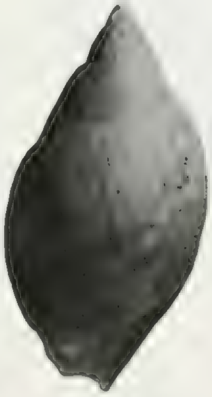
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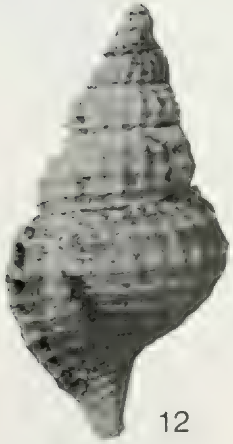
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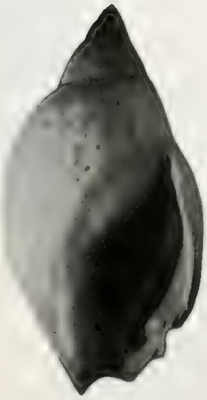
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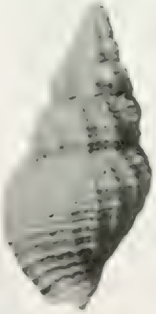
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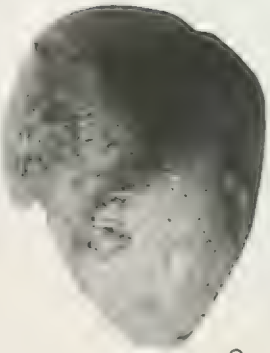
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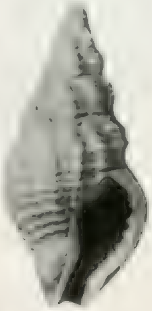
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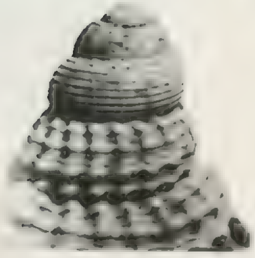
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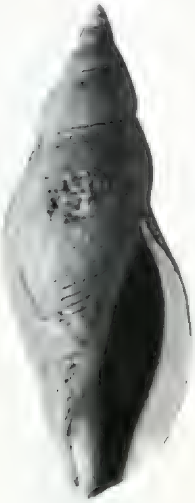
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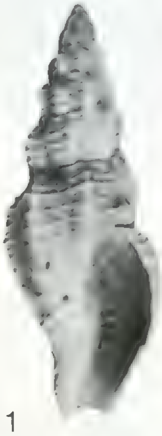
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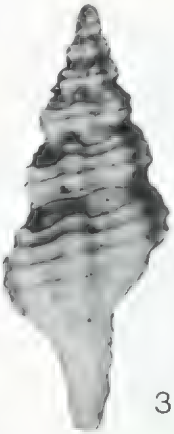
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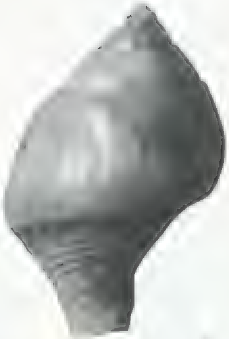
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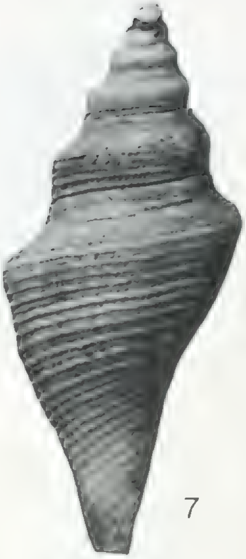
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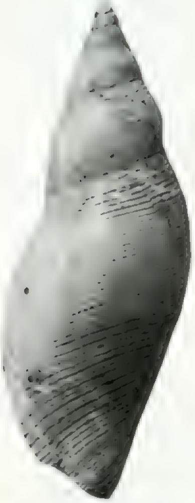
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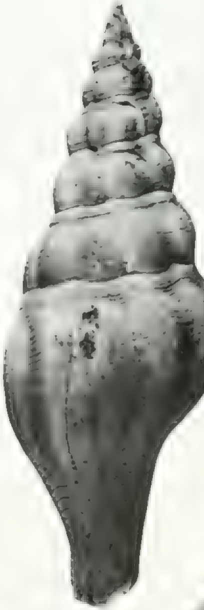
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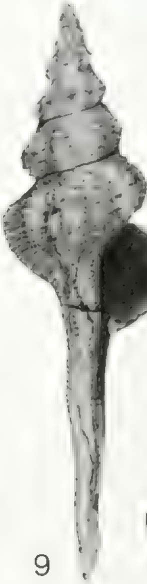
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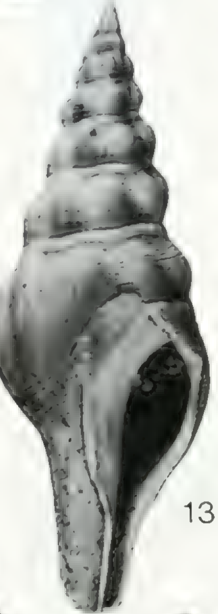
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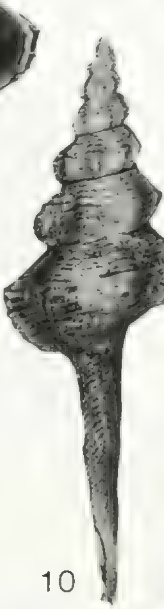
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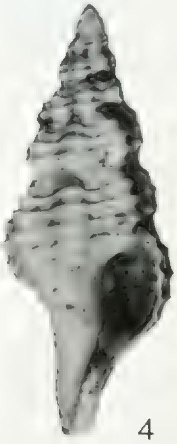
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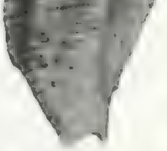
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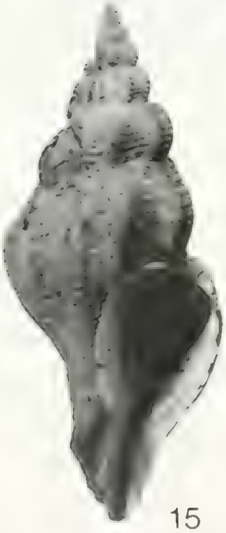
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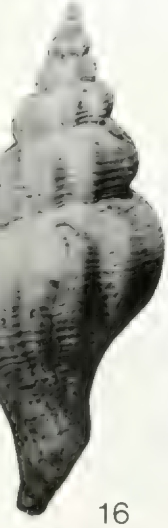
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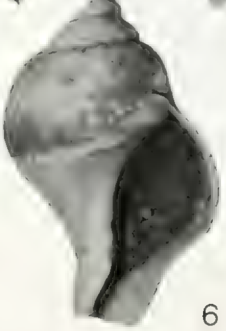
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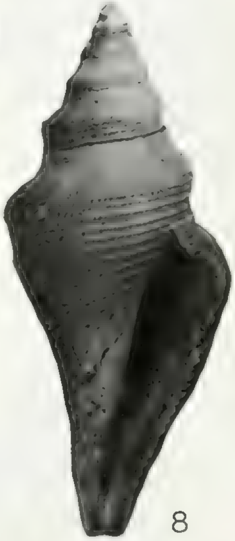
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EXPLANATION OF PLATE 16

Figure Page

1–2. ***Euryochetus punctatum,*** new species 83
Locality 4.
1–2. Front and rear views of the holotype, ×2 (PRI 30413).

3–4. ***Latirus (Polygona) traceyi,*** new species 76
Locality 4.
3,4. Rear and front views of the holotype, ×4.7 (PRI 30401).

5–6. ***Mazzalina conica,*** new species 77
Locality 14.
5,6. Rear and front views of the holotype, ×2.8 (PRI 30403).

7–8. ***Surculites lapillus,*** new species 78
Locality 20.
7,8. Rear and front views of the holotype, ×2.3 (PRI 30406).

9–10. ***Falsifusus ottonis*** (Aldrich) 75
Locality 21.
9,10. Front and rear views of a Reklaw specimen, ×1.6 (PRI 30447).

11–12. ***Terebrifusus multiplicatus*** (H. C. Lea) 77
Locality 20.
11,12. Front and rear views of the Reklaw specimen, ×7 (PRI 33180).

13–14. ***Clavilithes? acus,*** new species 79
Locality 4.
13,14. Front and rear views of the holotype, ×1.7 (PRI 30107).

15–16. ***Fusinus claibornica,*** new species 76
Locality 20.
15,16. Front and rear views of the holotype, ×1 (PRI 30399).

EXPLANATION OF PLATE 17

Figure Page

1–2. ***Clavilithes parvetorbis,*** new species 78
Locality 21.
1,2. Front and rear views of the holotype, ×0.9 (PRI 30408).

3–6. ***Cornulina minax dockeryi,*** new subspecies 80
Locality 4.
3,4,5. Rear, front and top views of the holotype, ×1.4 (PRI 30411).
6. Front view of a gerontic specimen, ×1.3 (PRI 33128).

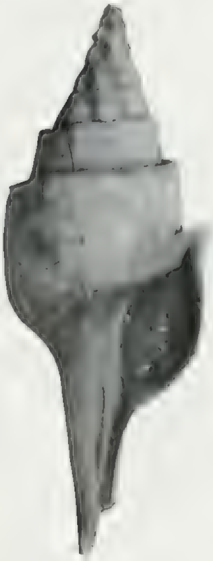
7–8. ***Laevibuccinum lineatum*** Heilprin 83
Locality 4.
7,8. Front and rear views of a Reklaw specimen, ×3.8 (PRI 30557).

9–10. ***Siphonalia*** cf. *plummeri* Palmer 84
Locality 20.
4,5. Rear and front views of a Reklaw specimen, ×2.9 (PRI 30420).

11–12. ***Strepsidura harrisi*** Givens and Garvie 82
Locality 20.
11,12. Front and rear views of a paratype, ×4.6 (PRI 33114).

13–14. ***Sycostoma texana,*** new species 81
Locality 20.
13,14. Rear and front views of the holotype, ×2 (PRI 30414).

15–17. ***Michela trabeatoides carinata,*** new subspecies 82
Locality 18.
15,16. Rear and front views of the holotype, ×2 (PRI 30327).
17. View of the nuclear whorls of a paratype, ×13. (Specimen lost).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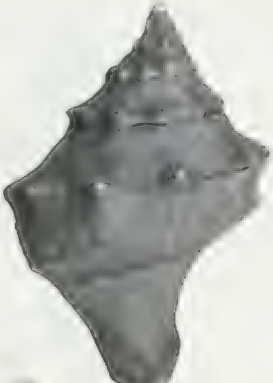
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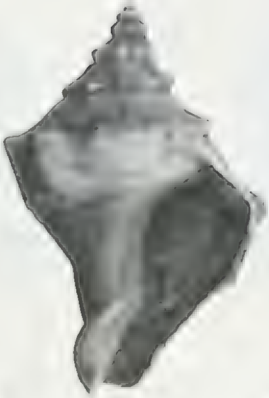
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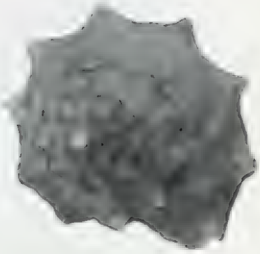
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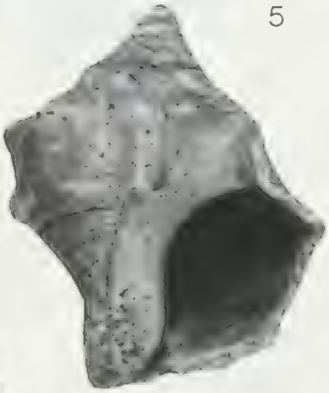
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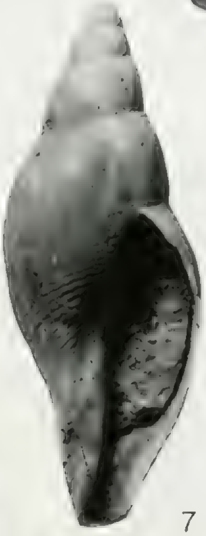
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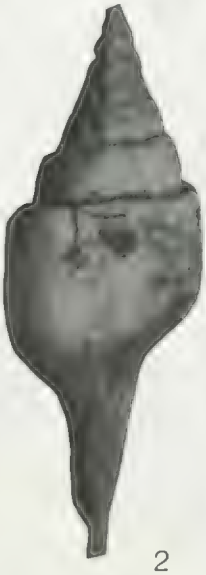
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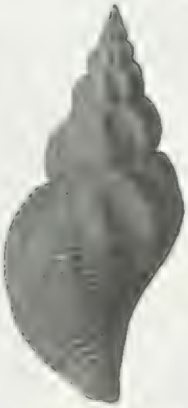
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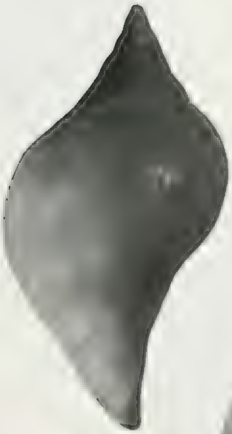
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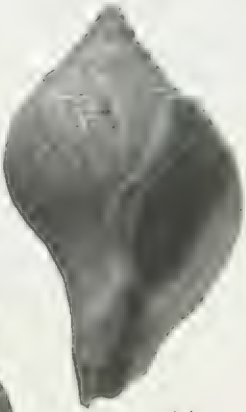
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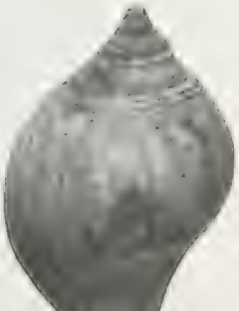
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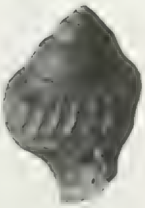
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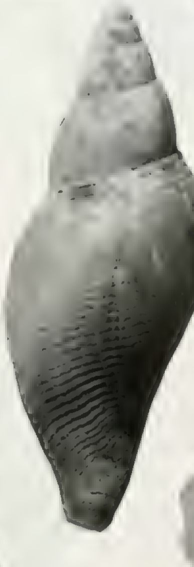
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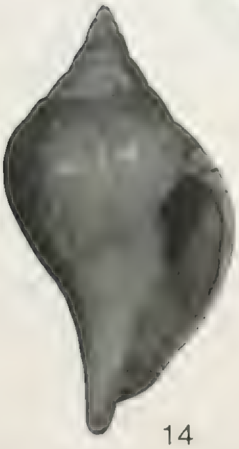
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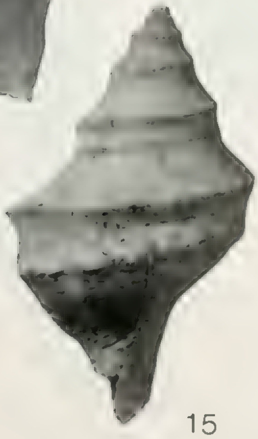
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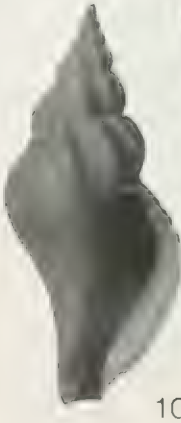
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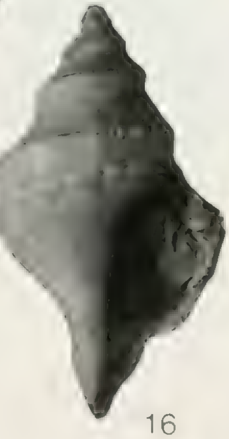
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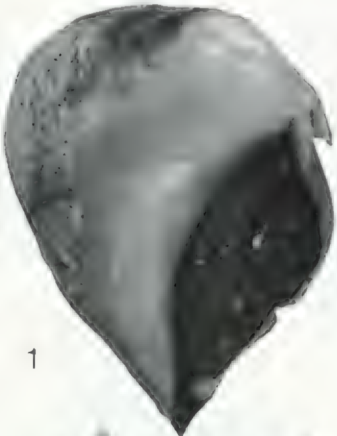
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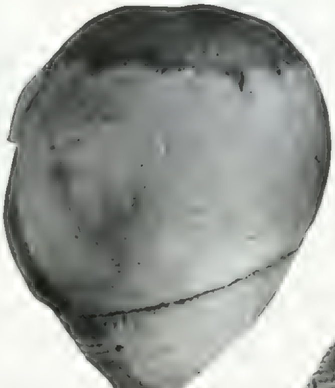
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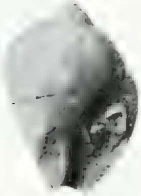
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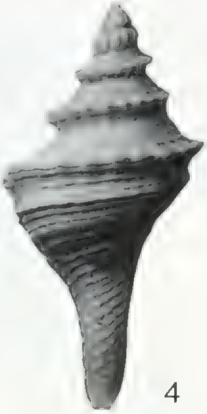
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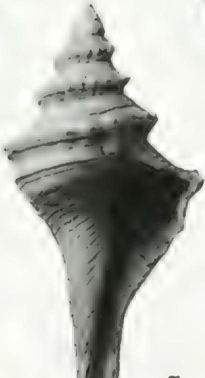
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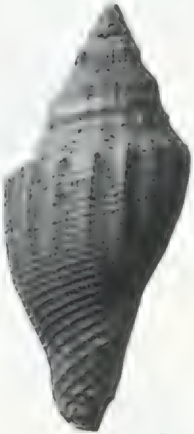
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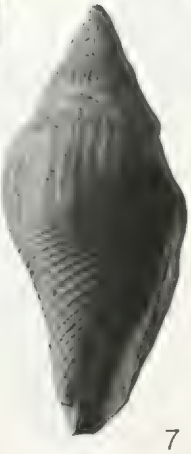
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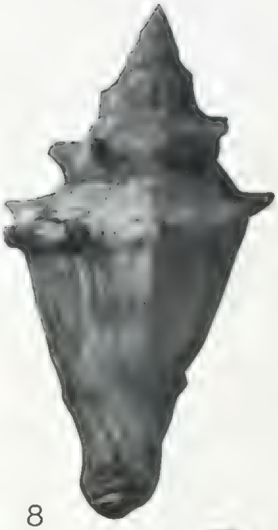
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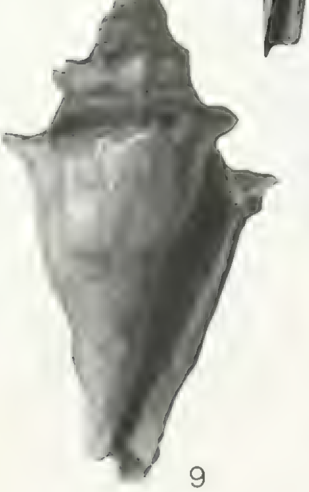
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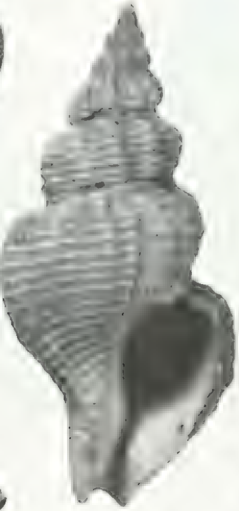
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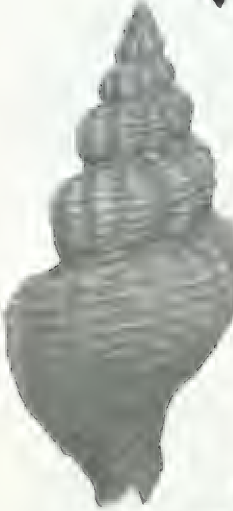
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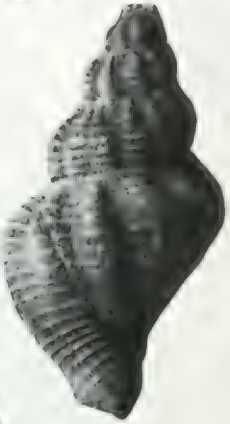
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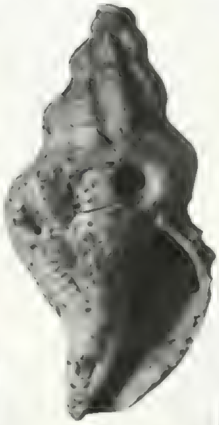
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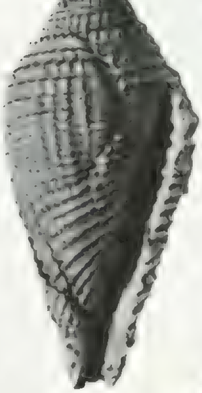
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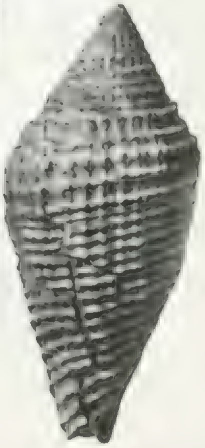
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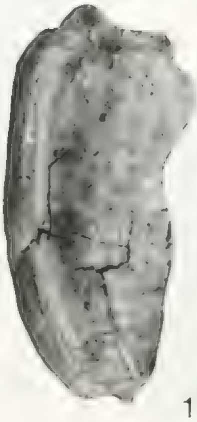
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EXPLANATION OF PLATE 18

Figure . . . Page

1–3. ***Pseudoliva*** cf. *santander* Gardner . . . 84
    Location 20.
    1,2. Front and rear view of an adult specimen, ×1.5 (PRI 30418).
    3. Front view of a juvenile, a paratype, ×1.6 (PRI 30419).

4–5. ***Levifusus? serrae,*** new species . . . 80
    Locality 20.
    4,5. Rear and front views of the holotype, ×13 (PRI 30464).

6–9. ***Athleta petrosus smithii*** Fisher and Rodda . . . 86
    6,7. Rear and front views of the smooth variety, ×3 (PRI 30422), from locality 20.
    8,9. Rear and front views of a gerontic spinose variety, ×1.7 (PRI 30425), from locality 20.

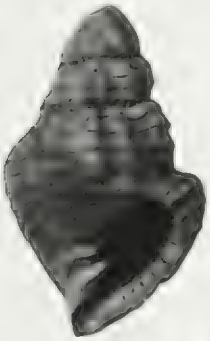
10–13. **Antillophos multilineatum,** new species . . . 73
    Location 20.
    10,11. Front and rear viws of the holotype, ×1.7 (PRI 30557).
    12,13. Rear and front views of a juvenile paratype, ×5.8 (PRI 30558).

14–15. ***Volutocorbis stenzeli*** (Plummer) . . . 85
    Locality 20.
    14,15. Front and rear views of a large individual, ×4 (PRI 30421).

16. ***Cryptochorda***? sp. . . . 86
    Locality 20.
    16. View of a fragment of body whorl, ×2.23 (PRI 33129).

EXPLANATION OF PLATE 19

Figure Page
1–2. ***Admetula irregularis,*** new species . . . 87
Locality 4.
1,2. Front and rear views of the holotype, ×11 (PRI 30427).
3–4. ***Trigonostoma (Ventrilia) herbae,*** new species . . . 88
Locality 20.
3,4. Front and rear views of the holotype, ×5.4 (PRI 30429).
5–6. ***Trigonostoma (Ventrilia) jonesae,*** new species . . . 89
Locality 20.
5,6. Front and rear views of the holotype, ×5.2 (PRI 30433).
7–8. ***Trigonostoma (Ventrilia) elegantissima,*** new species . . . 88
Locality 20.
7,8. Rear and front views of the holotype, ×6.1 (PRI 30432).
9–10. ***Conus (Lithoconus) nocens,*** new species . . . 90
Locality 11.
9,10. Front and top views of the holotype, ×3 (TMM 84822).
11–12. ***Volvariella milamensis,*** new species . . . 89
Locality 20.
11,12. Front and rear views of the holotype, ×5.9 (PRI 30435).
13–14. ***Turricula*** sp. . . . 91
Locality 20.
13,14. Front and rear views of a specimen, ×3 (PRI 30560).
15–16. ***Ancilla (Olivula) staminea reklawensis,*** new subspecies . . . 87
Locality 20.
15,16. Rear and front views of the holotype, ×3.5 (PRI 30425).
17–19. ***Coronia taylori,*** new species . . . 97
Locality 20.
18,19. Front and rear views of the holotype, ×3.4 (PRI 30561).
17. Apical view of a paratype, ×11 (PRI 30562).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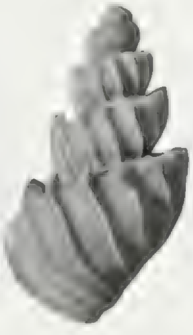
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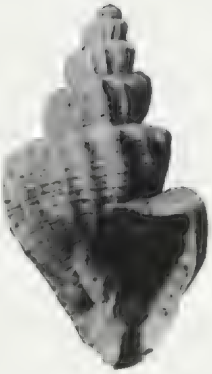
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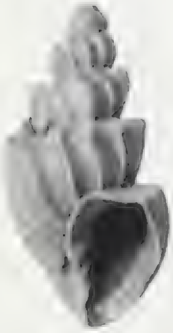
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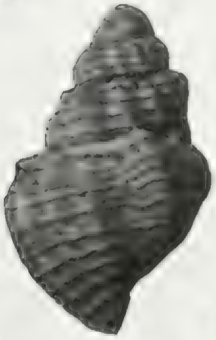
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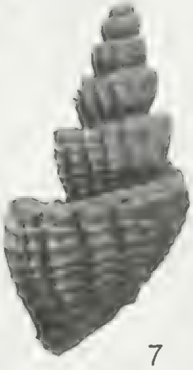
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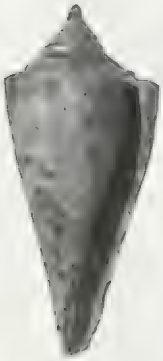
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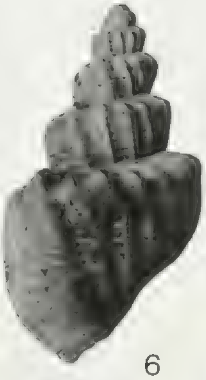
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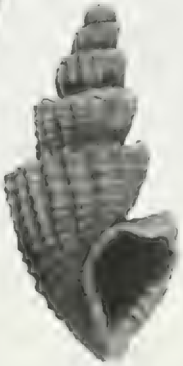
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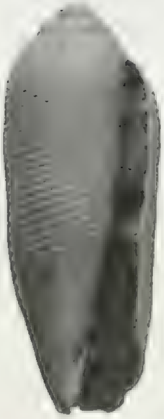
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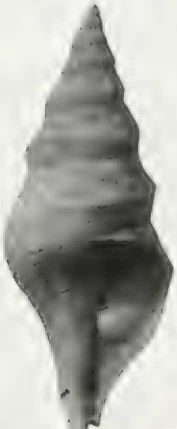
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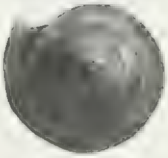
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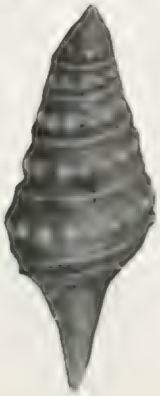
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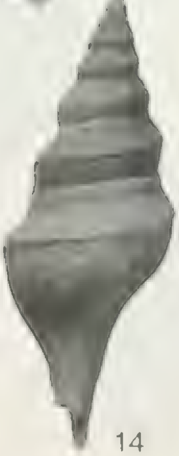
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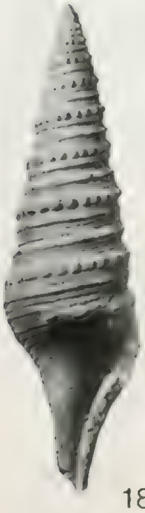
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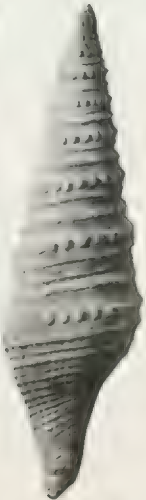
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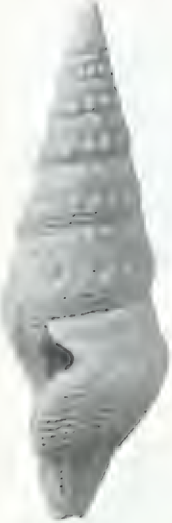
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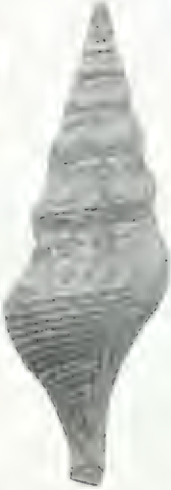
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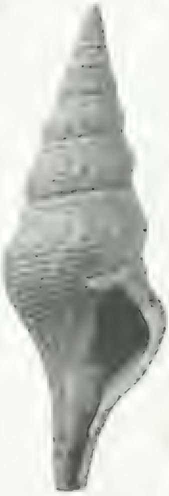
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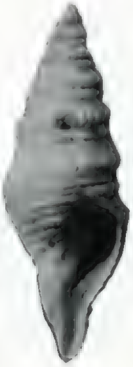
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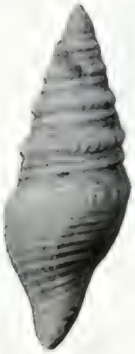
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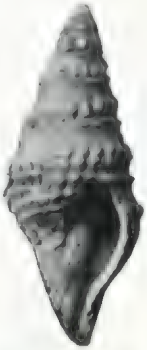
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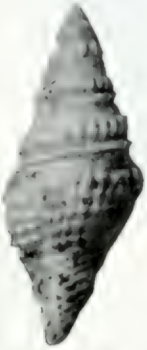
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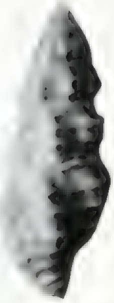
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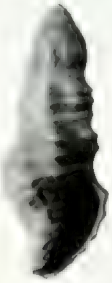
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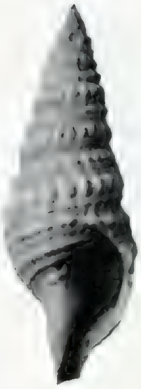
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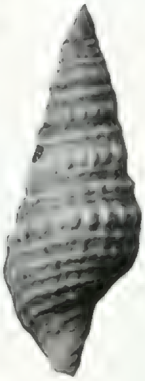
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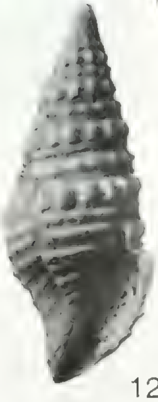
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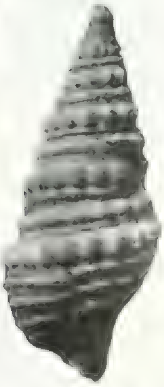
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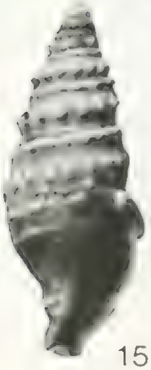
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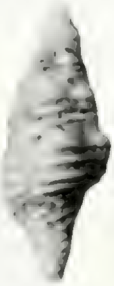
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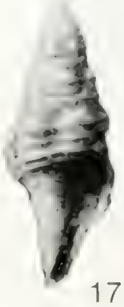
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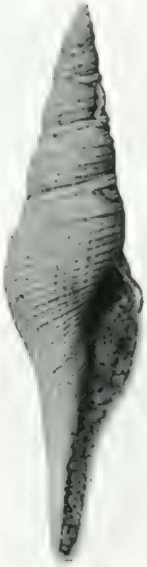
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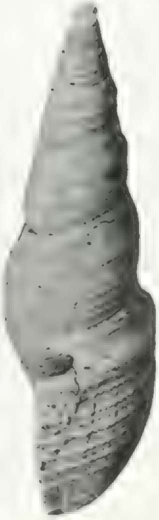
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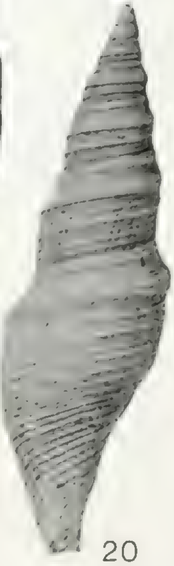
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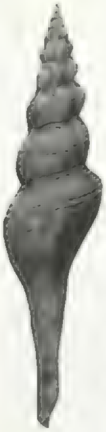
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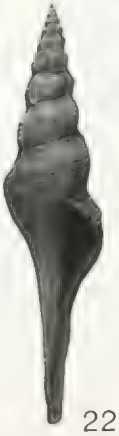
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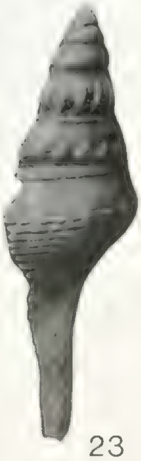
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EXPLANATION OF PLATE 20

Figure — Page

1–3. ***Hesperiturris nodocarinatus crassus,*** new subspecies — 98
Locality 20.
2,3. Rear and front views of the holotype, ×3.2 (PRI 30449).
1. View of a paratype, ×4.7 (PRI 30450).

4–5. ***Bathytoma*** cf. *nonplicata* Harris — 100
Locality 4.
5,6. Front and rear views of a Reklaw specimen, ×5.3 (PRI 30457).

6–7. ***Domenginella ridgei,*** new species — 100
Locality 4.
7,8. Front and rear views of the holotype, ×6.8 (PRI 30458).

8–9. ***Pyramimitra (Petrafixa) eocenica,*** new species — 92
Locality 20.
8,9. Rear and front views of the holotype, ×13 (PRI 30464).

10–11. ***Coronia*** cf. ***margaritosa*** Casey — 98
Locality 4.
10,11. Rear and front views of the Reklaw specimen, ×6 (PRI 33186).

12–13. ***Hesperiturris***? ***monilis,*** new species — 99
Locality 4.
12,13. Front and rear views of the holotype, ×6.2 (PRI 30454).

14. ***Surculoma (Volutapex) imbricata,*** new species — 91
Locality 20.
14. Front view of the holotype, ×2.3 (PRI 30460).

15. ***Hesperiturris***? ***monilis laeva,*** new subspecies — 99
Locality 4.
15. Front view of the holotype, ×7.7 (PRI 30448).

16–17. ***Lyrosurcula*** cf. *vaughani* (Harris) — 92
Locality 20.
16,17. Rear and front views of a Reklaw specimen, ×9.3 (PRI 33130).

18–20. ***Eosurcula moorei reklawensis,*** new subspecies — 94
Locality 20.
18. Front view of the holotype, ×5.3 (PRI 30470).
19. View of a paratype showing the sinus, ×3.75 (PRI 30471).
20. Rear view of a paratype, ×4.4 (PRI 30472).

21–22. ***Pleurofusia***? **huppertzi** (Harris) — 93
Locality 8.
21,22. Rear and front views of a Reklaw specimen, ×1.6 (PRI 30505).

23. ***Leptosurcula carinata,*** new species — 94
Locality 4.
23. Front view of the holotype, ×9.3 (PRI 30466).

EXPLANATION OF PLATE 21

Figure Page

1–2. ***Tropisurcula (Tropisurcula) milamensis,*** new species 95
Locality 20.
1,2. Rear and front views of the holotype, ×5.8 (PRI 30478).

3–4. ***Tropisurcula (Eodrillia) planus*** new species 96
Locality 20.
3,4. Rear and front views of the holotype, ×4.6 (PRI 30473).

5–6. ***Tropisurcula (Eodrillia) grandis,*** new species 96
Locality 4.
5,6. Rear and front views of the holotype, ×5.6 (PRI 30478).

7–8. ***Protosurcula****? aurora,* new species 96
Locality 20.
7. Rear view of the holotype, ×1.8 (PRI 30483).
8. Front view of a paratype, ×2.6 (PRI 30484).

9–11. ***Eocythara texana,*** new species 103
Locality 20.
9,10,11. Front, rear and side views of the holotype, ×10 (PRI 30489).

12–13. ***Microdrillia rostratula*** Casey 101
Locality 20.
12,13. Front and rear views of a Reklaw specimen, ×6.8 (PRI 30567).

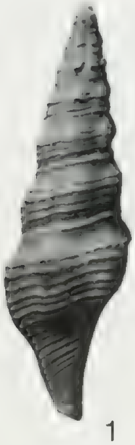
14–15. ***Microdrillia*** aff. *robustula* Casey 101
Locality 20.
14,15. Front and rear views of a Reklaw specimen, ×7.3 (PRI 33110).

16–17. ***Spirotropis claibornica,*** new species 102
Locality 4.
16,17. Rear and front views of the holotype, ×8 (PRI 30488).

18–19. ***Eocythara lineata,*** new species 103
Locality 20.
18,19. Rear and front views of the holotype, ×11.6 (PRI 30494).

20–21. ***Microdrillia*** sp. 101
Locality 4.
20,21. Front and rear views of a specimen, ×6.5 (PRI 30568).

22–23. ***Varicobela filum,*** new species 104
Locality 20.
22,23. Front and rear views of the holotype, ×5.9 (PRI 30569).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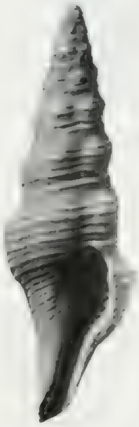
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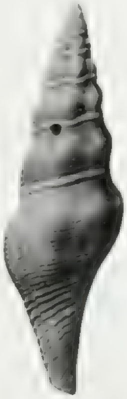
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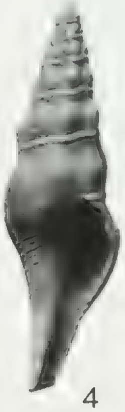
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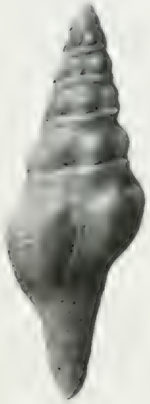
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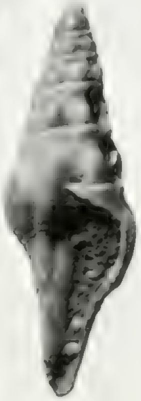
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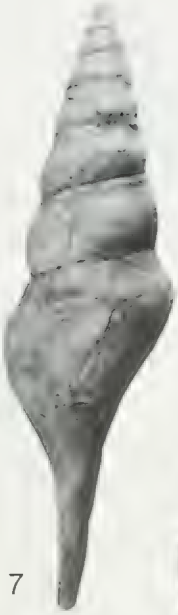
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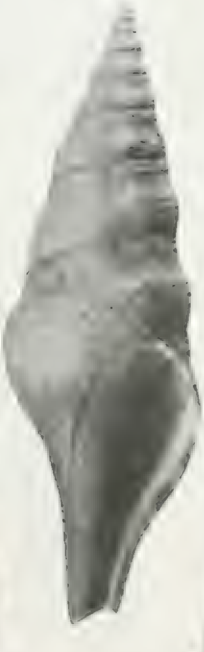
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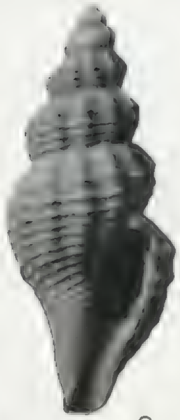
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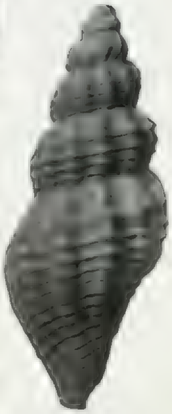
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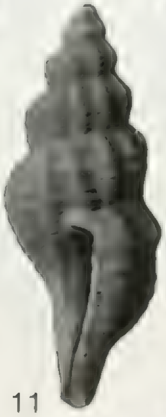
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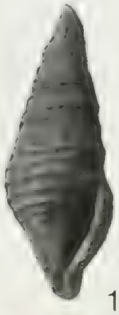
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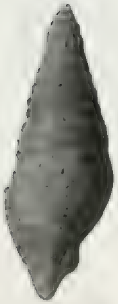
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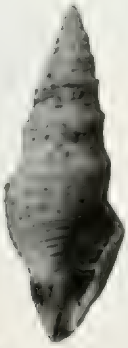
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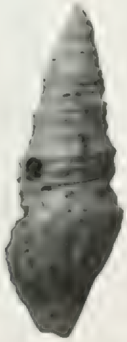
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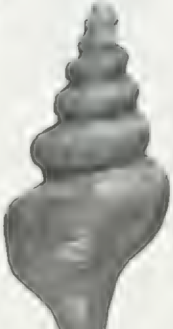
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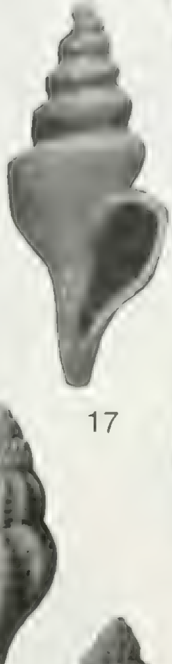
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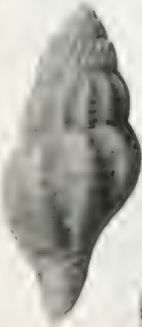
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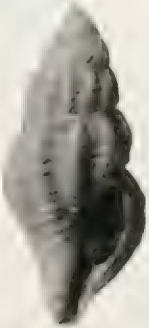
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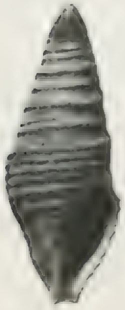
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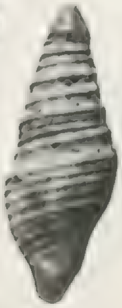
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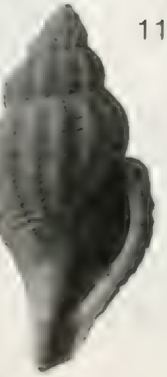
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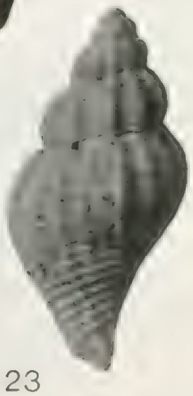
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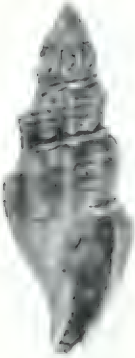
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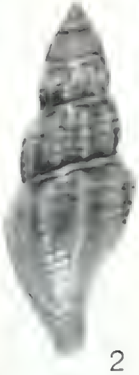
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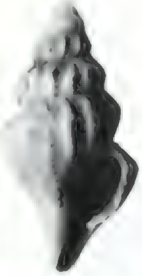
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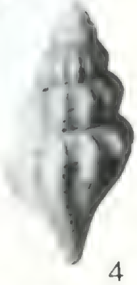
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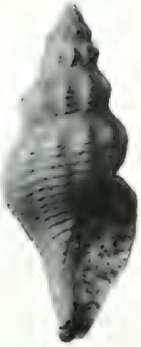
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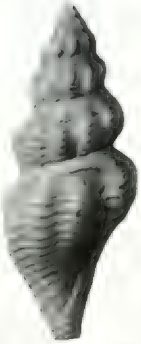
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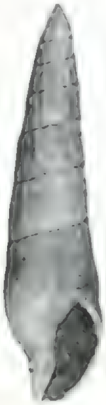
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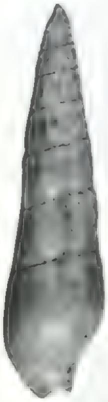
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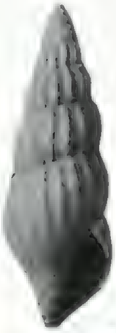
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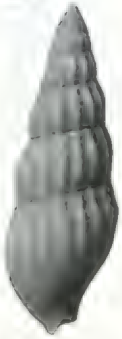
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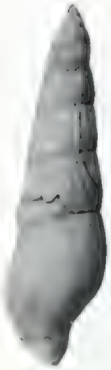
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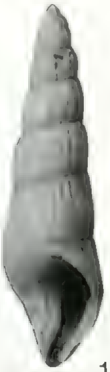
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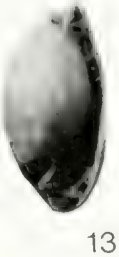
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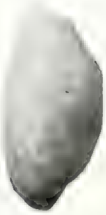
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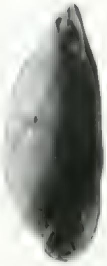
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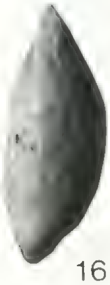
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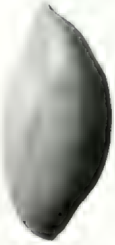
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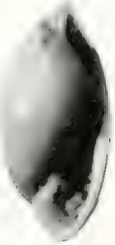
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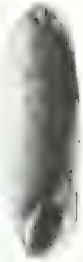
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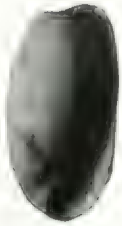
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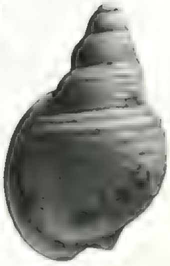
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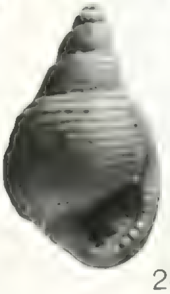
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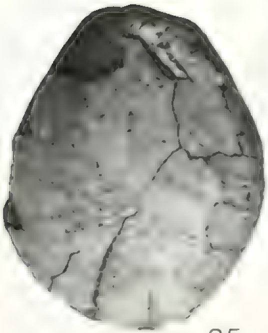
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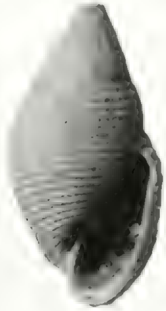
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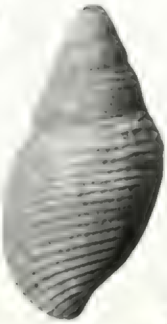
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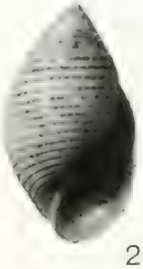
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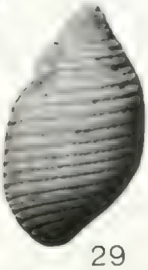
29

EXPLANATION OF PLATE 22

Figure		Page
1–2.	***Raphitoma (Microsurcula) georgei reklawensis,*** new subspecies Locality 20. 1,2. Front and rear views of the holotype, ×13 (PRI 30496).	105
3–4.	***Raphitoma (Microsurcula) bastropensis,*** new species Locality 4. 3,4. Front and rear views of the holotype, ×10 (PRI 30498).	105
5–6.	***Raphitoma (Microsurcula) iuventae,*** new species Locality 20. 5,6. Front and rear views of the holotype, ×8.2 (PRI 30500).	105
7–8.	***Hastula (Hastula) milamensis,*** new species Locality 20. 7,8. Front and rear views of the holotype, ×7 (PRI 30506).	112
9–10.	***Hastula (Bulbihastula) ampulla,*** new species Locality 20. 9,10. Front and rear views of the holotype, ×6 (PRI 30509).	112
11–12.	***Hastula (Bulbihastula) longifera,*** new species Locality 20. 11,12. Rear and front views of the holotype, ×5.5 (PRI 30514).	113
13–14.	***Mnestia confusa,*** new species Locality 4. 13,14. Front and rear views of the holotype, ×13 (PRI 30519).	113
15–16.	***Volvulella reklawensis,*** new species Locality 20. 15,16. Front and rear views of the holotype, ×13 (PRI 30520).	114
17–18.	***Mnestia rotunda,*** new species Locality 20. 15,16. Rear and front views of the holotype, ×13 (PRI 30517).	113
19–20.	***Retusa (Cylichnina) notata,*** new species Locality 20. 19,20. Front and rear views of the holotype, ×8.6 (PRI 30521).	114
21–22.	***Retusa (Cylichnina)*** cf. *adamski* Palmer Locality 4. 21,22. Front and rear views of a Reklaw specimen, ×13 (PRI 30445).	115
23–24.	***Ringicula trapaquara*** Harris Locality 14. 23,24. Rear and front views of a Reklaw specimen, ×20 (PRI 30524).	115
25.	***Philine*** sp. Location 4. 25. Side view of the specimen, ×2.5 (PRI 30404).	115
26–27.	***Semiacteon texanum,*** new species Location 4. 26,27. Front and rear views of the holotype, ×10 (PRI 33078).	117
28–29.	***Acteon pomilis punctatus*** I. Lea Location 2. 28,29. Front and rear views of a Reklaw spcimen, ×6.5 (30525 PRI).	116

EXPLANATION OF PLATE 23

Figure Page

1–2. ***Pyramidella (Syrnola) pirum,*** new species . . . 117
Locality 20.
1,2. Front and rear views of the holotype, ×13 (PRI 30526).

3–4. ***Pyramidella (Cossmannica) perexilis*** (Conrad) . . . 118
Locality 20.
3,4. Front and rear views of a Reklaw specimen, ×7.5 (PRI 30529).

5–6. ***Pyramidella (Cossmannica) tundrae,*** new species . . . 118
Locality 20.
5,6. Front and rear views of the holotype, ×8.5 (PRI 30405).

7–8. ***Pyramidella (Cossmannica) filamentosa,*** new species . . . 118
Locality 20.
7,8. Front and rear views of the holotype, ×10 (PRI 30530).

9–10. ***Pyramidella (Cossmannica) tundrae zigguratum,*** new species . . . 119
Locality 4.
9,10. Front and rear views of the holotype, ×30 (PRI 30479).

11–12. ***Odostomia (Doliella?) ova,*** new species . . . 119
Locality 4.
11,12. Front and rear views of the holotype, ×12 (PRI 30536).

13–15. ***Turbonilla (Ptycheulimella) meta,*** new species . . . 120
Locality 20.
13,14. Rear and front views of the holotype, ×13 (PRI 30541).
15. View of the early apical whorls of a paratype, ×30 (PRI 30542).

16–17. ***Turbonilla (Pyrgiscus)*** sp. . . . 120
Locality 20.
16,17. Front and rear views of the specimen, ×17 (PRI 30480).

18. ***Turbonilla*** cf. ***neglecta*** Meyer . . . 120
Locality 4.
18. Front view of a fragment of a Reklaw specimen, ×13 (PRI 30540).

19. ***Melanella*** aff. ***extremis*** (Aldrich) . . . 67
Location 20.
19. Front view of a repaired specimen, ×10 (PRI 30417).

20–21. ***Melanella minutissima,*** new species . . . 66
Locality 20.
20,21. Rear and front views of the holotype, ×20 (PRI 30546).

22–24. ***Melanella*** cf. ***notata*** (I. Lea) . . . 66
Locality 14.
22,23. Front and rear views of the Reklaw specimen, ×13 (PRI 33105).
24. Front view of a larger, but somewhat crushed specimen, ×5.4, from locality 20 (PRI 33131).

25–26. ***Umbraculum tomaculum,*** new species . . . 121
Location 21.
25,26. Top and side views of the holotype, ×3.4 (PRI 33075)

27–28. ***Belosaepia penna,*** new species . . . 121
Location 20.
27,28. Anterior-dorsal and side views of the holotype, ×3 (PRI 33130).

29–30. ***Aturia turneri*** (Stenzel) . . . 123
Location 6.
29,30. Ventral and apertural views of the holotype, ×0.53 (UT-TMM 20905). Figures reproduced with permission of the Texas Bureau of Economic Geology, from University of Texas Publication No. 3945.

30–31. ***Angulithes elliotti*** (Stenzel) . . . 122
Location 6.
30,31. Ventral and apertural views of the holotype, ×0.6 (UT-TMM 20901). Figures reproduced with permission of the Texas Bureau of Economic Geology, from University of Texas Publication No. 3945.

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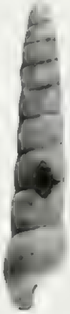
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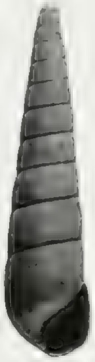
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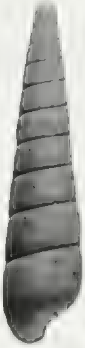
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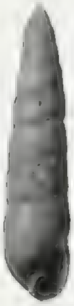
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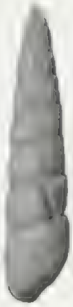
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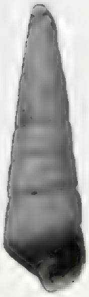
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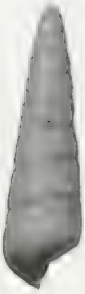
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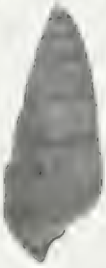
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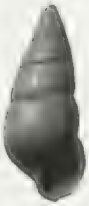
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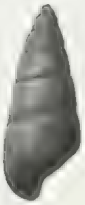
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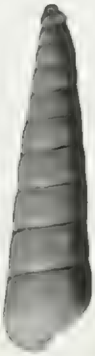
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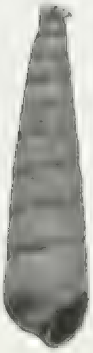
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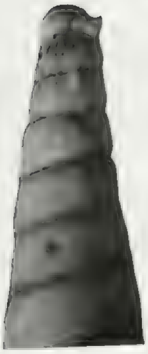
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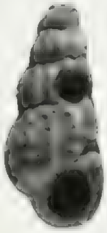
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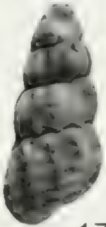
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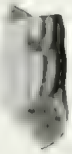
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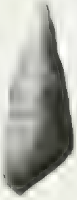
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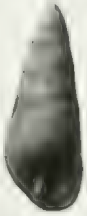
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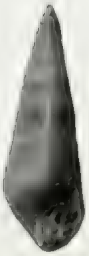
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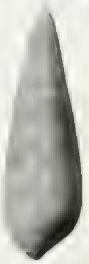
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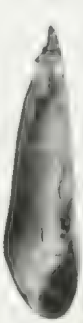
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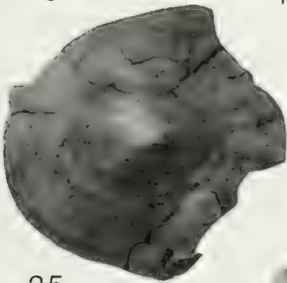
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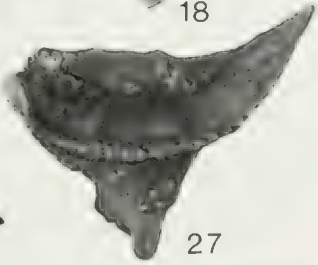
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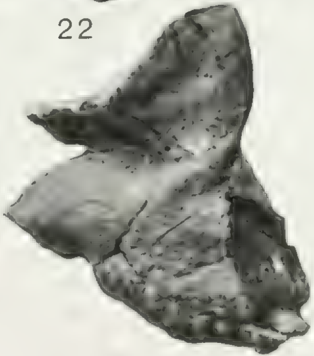
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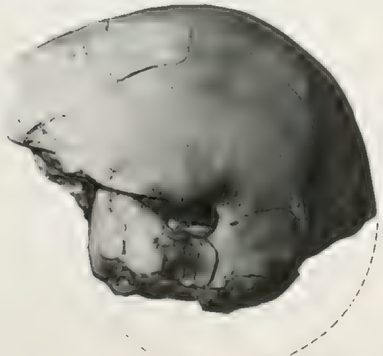
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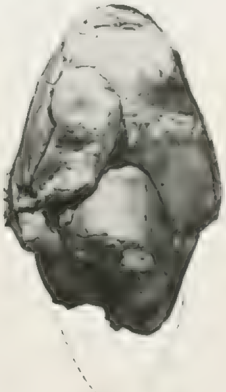
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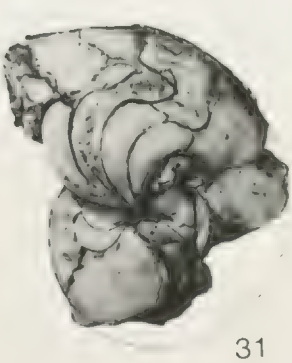
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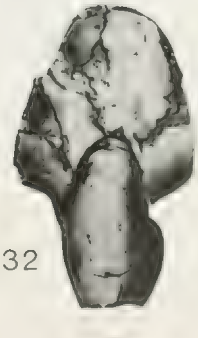
32

INDEX

Note: Numbers in **bold** refer to plates.

- Abbott (1974) 16
- *abruptus, Solen (Eosolen) lisbonensis* 36
- *acala, Leda* 23
- *Acamptogenotia* Roverato 104
- *Acar* Gray 26
- *acicula, Episiphon* 45
- *Acrocoleum bouryi* 106
- *Acteon* Montfort 16
  - *annectens* 116
  - *pomilis punctatus* **22**,116
- *acuminata, Bulla* 114
- *acus, Clavilithes*? **16**,79
- *acuta, Pseudomalaxis*? **10**,109
- *acutirostra, Pleurotoma* 97
- *adamski, Retusa (Cylichnina)* cf. 115
- *Adelocythara* Woodring 103
- *Admetula* Cossmann 87
  - *irregularis* **19**,88
  - *parilis* 88
  - *tortiplica* 88
- Afshar (1969) 37
- *agrestis, Turbonilla (Pyrgiscus)* 121
- *alabamensis,*
  - *Amusium (Propeamusium)* 31
  - *Corbula* 40
  - *Mitrella* 69
  - *Philine (Megistostoma)* 116
- *alba, Anodontia* 32
- *albirupina, Tritiaria* 73
- *albus, Polinices* 58
- *aldrichi,*
  - *Mathilda (Mathilda)* cf. *retisculpta* **10**,106
  - *Varicobela* 104
- *alticostata, Cardita* 35
- *altilis, Bullia* 75
- Alum Creek 11,14
- *alveata,*
  - *Architectonica* 110
  - *Sveltia* 89
- *alveatum, Solarium* 109
- *Alveinus* Conrad 38
  - *minutus* **7**,38
- *Amaea* H. and A. Adams 64
  - *(Foratiscala) texana* **12**,65
  - *(Scalina) macula* **12**,64
  - *(Scalina) staminea* 64
  - *(Scalina) trapaquara* 64
  - *(Scalina) trapaquara engonata* 64
- *Amaurellina* Fisher 57
  - *caleocia* 57
  - *plummeri* **12**,57
  - *singlei* 57
- *americana*
  - *Glyptozaria* **10**,108
  - *Postalia* **13**,54
- *americanae, Sycostoma* 81
- *amoenum, Buccinum* 77
- *amoenus, Terebrifusus* 73
- *amosi, Metula* 70
- *ampla, Voluta* 87
- *ampulla, Hastula (Bulbihastula)* **22**,112
- *Ampullaria spirata* 57
- *Ampullina waihaoensis* 58
- *Amusium* (Bolton) Roding 31
  - *(Propeamusium) alabamensis* 31
  - *(Propeamusium) squamulum* 31
  - *(Propeamusium) zinguli* **4**,31
- *Ancilla* Lamarck 87
  - *(Olivula) staminea* 87
  - *(Olivula) staminea reklawensis* **19**,87
- *Angulithes* Montfort 122
  - *elliotti* **23**,14,122
- *annectens, Acteon* 116
- Annelids 8
- *Anodontia* Link 32
  - alba 32
- *Anodontia (Eophysema)*
  - *ozarkana* 33
  - *reklawensis* **5**,33
  - sp. 33
  - *subvexa* 33
- *antiqua, Cochlodesma* 43
- *anus, Distorsio* 71
- *Anatina leana* 43
- Angelina River 15
- *annosa, Surculites* 78
- *Antalis* H. and A. Adams 46
- *antalis, Dentalium* 46
- *Antillophos* Woodring 72,73,74
  - *multilineatum* **18**,73
- *aperta, Bulla* 116
- *apertus, Theodoxus* 47
- *aratus, Polinices* 59
- *Arca*
  - *barbata* 25
  - *fragilis* 23
  - *gradata* 26
  - *lissa* 27
  - *nucleus* 21
  - *pectunculoides* 27
  - *pernula* 22
- *Architectonica* Röding 109
  - *alveata* 110
  - *(Granosolarium) aldrichi caterva* **11**,111
  - *(Granosolarium) geminicostata* **11**,111
  - *(Granosolarium) meekana* 110
  - *(Patulaxis?) fimbriaea* **11**,110
  - *scrobiculata* 110
  - *(Stellaxis) reklawensis* **11**,109
  - *sylvaerupis* 110
- *arctatum, Sinum* 59
- Arthropods 8,15
- *arcaforma, Gregariella* 29
- *Architectonica (Stellaxis) reklawensis* 15
- *Arcopagia* Brown 37
- *Arcopagia (Arcopagia)*
  - *trumani* **6**,38
  - *trumani australina* 38
- *Argyropeza* Melville and Standen
  - *armigera, Cornulina* 80

arnoldi, Callocallista 40
aspera, Barbatia (Acar) 26
Astyris 69
Athleta Conrad 86
  petrosus smithii **18**,86
  tuomeryi 86
atakta, Leda 24
Athleta petrosa smithii **18**,14,15
Atrina Gray 29
  sp. **3**,30
attenuata, Cardiomya 44
aturi, Nautilus 123
Aturia Bronn 123
  turneri **23**,14,123
aurantiacus, Latirus 76
Auricula ringens 115
aurora, Protosurcula? **21**,15,97
australina, Arcopagia (Arcopagia) trumani 38
autopsis, Eutritonium (Epidromus) 73
axacuus, Cyclostremiscus **9**,51

Balcis 67
Bankia Gray 42
  emacerata 43
  maverickensis 42
  ringens 43
Bankia (Lyrodobankia) petalus **8**,42
Bannahan (1950)
barbata, Arca 25
Barbatia Gray 25
  sp. 27
  uxoripalmeri 26
Barbatia (Acar)
  aspera 26
  salebrosus **2**,26
Barbatia (Cucullaearca) reklawensis **2**,25
basterot, Terebra (Myurella) 112
Bastrop County 9,11
bastropensis,
  Litorhadia? 25
  Pitar (Katherinella?) trigoniata 40
  Raphitoma (Microsurcula) **22**,105
Bathyarca Kobelt 27
  claibornica **3**,27
  hendersoni 27
Bathytoma Harris and Burrows 100
  cf. *nonplicata* **20**,100
beadata, Pleurotoma 94
Bela Gray 105
Belosaepia Voltz 122
  penna **23**,122
  sepioidea 122
  tricarinata 122
benoisti, Hastula 112
Bifrontia zanclaea 108
Bigford Formation 9
bilineata, Colwellia **15**,71
bipalmulata, Teredo 42
bisissura, Cadulus (?) **9**,46
bisulcata, Cassis 62
Bittium Leach in Gray 48
  (Bittium) estellense 49
  longissimum 49
  ridgei **10**,14,49,64
  tresquatrum **10**,48–49
Bolis Gardner 81
  enterogramma 81
Bombshell Bluff 7,14
bouryi, Acrocoleum 106
brazosensis, Metula 70
brevialis, Turritella 50
brevicostatum, Phalium 62
brevisulcata, Natica (Naticarius) **12**,57
britannicus, Clavilithes 79
Bryozoans 8
Buccinanops d'Orbigny 74
  ellipticum reklawensis **15**,15,74
bucciniformis, Mitrella (Clinurella) 68
Buccinum
  amoenum 77
  cassidariaeformis 84
  cochlidum 74
  cylindraceum 83
  echinophorum 60
  glauca 62
  metula 69
  mississippiensis 72
  plumbeum 84
  prorsum 83
  stromboides 87
bulbiformis,
  Fusus 81
  Sycostoma pyrus 81
bulbus, Cypraeorbis **13**,15,56
Bulbifusus Conrad 77
Bulbihastula new subgenus 112
Bulla
  acuminata 114
  aperta 116
  eburnea 114
  marmorata 113
Bullia Gray 74
  altilis 75
  altilis harrisi **15**,74
  semiplicata 74
bulimoides, Spirotropis (Antiplanes) cf. 102
Byssoarca lima 26

cabezi, Surculites 78
Cadulus Philippi 46
  bisissura, (?) **9**,46
  (Gadila) erleneae 47
  (Gadila) ouachitensis 47
  (Polyschides) subcoarcuatus **9**,47
  spp. 47
caelatura, Phalium (Semicassis) 62
cainei, Eopleurotoma 99
caleocia, Amaurellina 57
calliope, Clinura 80
Callista sulcataria 39
Callocallista arnoldi 40
Calorhadia
  houstonia 23
  pharcida 23
Calpitaria Jukes-Browne 39
canalis, Strombus 54
Cancellaria
  candei 73
  evulsa 87
  tenera 88

candei, Cancellaria 73
candida, Pholadomya 43
Cane River Formation 9
canrena, Nerita 57
cantonis, Pachecoa 28
Cardiapoda d'Orbigny 52
cardiiformis, Hippagus 45
Cardiomya A. Adams 44
  attenuata 44
  curta 44
  fredsmithi **8**,44
  gouldiana 44
  sp. **8**,44
Cardita alticostata 35
Carinacca Marwick 58
carinata,
  Leptosurcula **20**,94
  Michela trabeatoides **17**,82
carinatum, Pleurotoma? 102
Carrizo Springs 9
Caryocorbula Gardner 40
  deusseni 41
  marquezensis **7**,40
caseyi,
  Pleurotoma (Drillia) 95
  Tropisurcula 95
Cassidaria planotecta 60
cassidariaeformis, Buccinum 84
Cassis bisulcata 62
cataphractus, Murex 100
catasarca, Nuculana (Saccella) 23
caterva, Architectonica (Granosolarium) aldrichi **11**,111
ceciliae, Pectin (Propeamusium) 31
Cerithiella dertobcarinata 64
cerithiformis, Scalaria 65
Cerithiopsina Bartsch 63
Cerithiopsis Forbes and Hanley 63
  (Cerithiopsis) necropolitana 63
  (Cerithiopsina?) sp. **12**,63
Cerithium fimbriatum 107
Chama Linnaeus 33
  harrisi 34
  lazarus 33
  monroensis 34
  (Psilopus) mississippensis 34
  taylorensis **5**,34
Charitodoron Tomlin 83
Charonia (Sassia)
  columbrina 73
  formosum 73
chavani, Pyramidella (Ulfa) 118
Cherokee County 8,9,11
chichoreum, Murex 67
childreni,
  Coronia 98
  Pleurotoma 97
chinensis, Umbrella 121
Cirsochilus Cossmann 52
Cirsotrema (Coroniscala) nassulum 64
claibarena, Pleurofusia 94
claibornensis,
  Mathilda (Mathilda), cf. **10**,107
  Mesalia 50
claibornica,
  Bathyarca **3**,27
  Fusinus **16**,15,76
  Spirotropis **21**,102
Claibornicardia Stenzel and Krause 35
  coloradonis subsp. **5**,35
  coloradonis texalana 35
  linguinodifera milamensi **5**,35
clandestina, Pyramidella 118
Classification 20
Clatrhurella Carpenter 103
Clathurellinae H. and A. Adams 102
Clavilithes Swainson 78
  britannicus 79
  kennedyanus 79
  longchaeus 78
  parvetorbis **17**,14,15,78
  scalaris 79
Clavilithes? acus **16**,79
claytonensis, Turris 100
clinensis, Turbonilla (Ptycheulimella) 120
Clinura Bellardi 80
  calliope 80
Clinurella Sacco 68
cochlear, Nucula **1**,22
cochlidum, Buccinum 74
Cochlodesma Couthouy 43
  antiqua 43
Cochlodesma (Cochlodesma) ovalis **8**,43
Cochlespira engonata 102
coloradonis subsp.,*Claibornicardia* **5**,35
columaria, Glyptozaria 108
Columbella (Clinurella) scalaris 68
Columbraria 70
  (Columbraria) lucasensis 70
  (Columbraria) siphonata 70
columbrina, Charonia (Sassia) 73
colus, Murex 75
Colwellia Nuttall and Cooper 71
  bilineata **15**,71
  flexuosa 71
  sp. **15**,72
Composition of the fauna 17
compressa, Cornulina minax 81
concava, Nucula 22
concentrica, Pachecoa **3**,27
confusa, Mnestia **22**,113
conica, Mazzalina **16**,77
conicus, Solariorbis **9**,53
conradiana,
  Sassia (Sassia) 73
  Volvulella 114
Conus Linnaeus 90
  marmoreus 90
  millepunctatus 90
  (Lithoconus) nocens **19**,90
  (Lithoconus) sauridens 90
cooperi, Rugatiscala **12**,68
Corals 8,15,56
Corbula alabamensis 40
Cornulina Conrad 80
  armigera 80
  dalli 80
  minax compressa 80

  minax dockeryi **17**,80
corona, Mathilda (Echinimathilda) 107
coronata, Galeodea 61
Coronia de Gregorio 97
  childreni 98
  genitiva 98
  margaritosa, cf. **20**,98
  taylori **19**,97
corrugata, Cyclothyca 55
cossmanni,
  Pleurotoma 101
  Rissoena (Leanella) 66
Cosmannica Dall and Bartsch 118
costata, Strepsidura 82
crassa,
  Retusa 114
  Tellina 37
crassus, Hesperiturris nodocarinatus **20**,98
Crenella isocardioides 29
crenulimarginata, Ostrea 32
Crenomytilus Soot-Ryan 28
  grayanus 29
  sp. **3**,29
creola, Plicatula 32
cribraea, Mathilda (Echinimathilda?) **10**,107
Cryptochorda Mörch 87
  eureia 87
  sp. **18**,87
Cucullaearca Conrad 26
curta, Cardiomya 44
Cyclostremiscus Pilsbry and Olsson 51
  axacuus **9**,51
Cyclothyca corrugata 55
Cylichna Lovén 114
Cylichnina Monterosato 114
  laevisculpta 114
Cylindites Sowerby 90
cylindraceum, Buccinum 83
Cypraeorbis bulbus **13**,56
Cypraeorbis
  bulbus 15,56
  lineata 56
  towncreekensis 56
  ventripotens 56

dalli, Cornulina 80
Daphnellinae Casey 104
Daphnobella Palmer 69,70
David's Bottom 14
Davis (1961)
decisa, Pachecoa 28
dekayi, Mnestia 113
declive, Sinum 59
Delphinula
  depressa 52
  trigonostoma 88
demissa, Nuculana (Saccella) **1**,23
Dentalium Linnaeus 46
  antalis 46
  elephantium 46
  ovulum 46
  sowerbyi 45
Dentalium (Antalis)
  palmerae **9**,46
  thalloides 46
Depositional environment 17–20
depressa, Delphinula 52
depygis, Pleurotoma 95
Dermatomya? harrisi 36
dertobcarinata, Cerithiella 64
Desorinassa Nuttal and Cooper 71,72
deusseni, Caryocorbula 41
Devil's Eye
  fossils 7,11
  locality 10,14
Diagonalus Pilsbry and McGinty 53
discoides, Solariorbis **9**,52
Distorsio Röding 71
  (Personella) nucleoides **15**,71
  (Personella) septemdentata 71
Dockery (1993) 20
dockeryi,
  Cornulina minax **17**,80
  Philine (Megistostoma) 116
dolabratus, Trochus 117
Domenginella Vokes 100
  ridgei **20**,100
domicilium, Theodoxus **9**,47
Dorsanum 72
Drillia laevis 96
dubia, Galeodea 61
dufresnii, Melanella 66
Dumble (1892) 10,14
dumblei, Turritella 50
Dunlap (1955) 9

eburnea, Bulla 114
echinophorum, Buccinum 60
Ectinochilus Cossmann 54
  sp. **14**,54
Echinoids 14
Echinimathilda Sohl 107
edulis, Mytilus 28
elegans, Lyrosurcula 92
elegantissima, Trigonostoma (Ventrilia) **19**,89
elephantium, Dentalium 46
elevata, Eosinica 121
Elisor (1929) 9
elliotti, Angulithes **23**,14,122
ellipticum reklawensis, Buccinanops **15**,15
elongatoides, Metula **15**,69
emacerata, Bankia 43
engonata,
  Amaea (Scalina) trapaquara 64
  Cochlespira 102
Environment 16–18
eoa, Hexaplex **14**,14,67
Eoatlanta Cossmann 52
Eocene stratigraphy 7
eocenensis, Verticordia 44
eocenica, Pyramimitra (Petrafixa) **20**,92
Eoclathurella Casey 103
Eocythara new genus 102,104
  lineata **21**,103
  texana **21**,103
Eodrillia Casey 95
  texana 96
  texanopsis 96
eofasciata, Littorina (Prosthenodon) **9**,50
Eophysema Stewart 33

- *Eopleurotoma* Cossmann 95
  - *cainei* 99
- *Eosinica* Aldrich 121
  - *elevata* 121
- *Eosolen shirleyi* **5**,36
- *enstrictus, Hesperiturris nodocarinatus* 99
- *Eosurcula* Casey 94
  - *moorei reklawensis* **20**,94
- *enterogramma, Bolis* 81
- *Episiphon* Pilsbry and Sharp 45
  - *acicula* 45
  - *gracilis* **9**,45
- *Epitonium* 64
- *erleneae, Cadulus (Gadila)* 47
- *estellense, Bittium (Bittium)* 49
- *euglypta, Glyptozaria* 108
- *Eulimella* Gray 120
- *eureia, Cryptochorda* 87
- *Euryochetus* Cossmann 83
  - *punctatum* **16**,83
- *Eurytellina* Fisher 37
- *Euspira marylandica* 58
- *Eutritonium (Epidromus) autopsis* 73
- *evulsa, Cancellaria* 87
- *extremis, Melanella,* aff. **23**,67

- *Falsifusus* Grabau 75
  - *ottonis* **16**,75
- *fastidiosa, Metula* 70
- Fauna, habitat 16
- *fernandoensis, Spirotropis (Antiplanes) perversa* 102
- *Ficopsis* Conrad 63
  - *nucleoides* **14**,63
- *filamentosa,*
  - *Plicatula* 31
  - *Pyramidella (Cossmannica)* **23**,118
- *filogranata, Mathilda (Fimbriatella)* 108
- *filum, Varicobela* **21**,104
- *fimbriaea, Architectonica (Patulaxis?)* **11**,110
- *Fimbriatella* Sacco 107
- *fimbriatum, Cerithium* 107
- *fiski, Sinum* 59
- *flammea, Turricula* 91
- *flexuosa, Colwellia* 71
- *fluviatalis, Nerita* 47
- Foraminifera 8,9
- *Foratiscala* de Boury 65
- *formosum, Charonia (Sassia)* 73
- *fragilis, Arca* 23
- *fredsmithi, Cardiomya* **8**,44
- *fusiformis, Polygona* 76
- *Fusinus* Rafinesque 75
  - *claibornica* **16**,15
  - *nexilis* 76
- *Fusus*
  - *bulbiformis* 81
  - *koeneni* 92
  - *meyeri* 75
  - *trabeatus* 79
  - *valenciennesii* 76

- *gabbi,*
  - *Metula* 70
  - *Protosurcula* 97
  - *Retusa (Cylichnina)* 115
  - *Surcula* 96
- *gabbiana, Volvariella* 90
- *gabbianum, Philine (Megistostoma)* 116
- *Galeodea* Link 60
  - *coronata* 61
  - *dubia* 61
  - *(Gomphopages?) millsapsi* 60
  - *(Mambrina) koureos* 60
  - *(Mambrina) turneri* **14**,14,15,61–62
- Gardner (1932) 9
- Gardner (1933) 6
- *Gegania* Jeffreys 106
  - *antiquata texana* **10**,106
  - *pinguis* 106
- *geminicostata, Architectonica (Granosolarium)* **11**,111
- *gemmatum, Trigonostoma* 88
- *genitiva, Coronia* 98
- *glauca, Buccinum* 62
- *gliberti, "Natica"* 58
- *Glyptotoma* Casey 100
- *Glycymeris* da Costa 28
  - *orbicularis* 28
  - sp. **3**,28
  - *trigonella* 28
- *glycymeris, Mya* 41
- *Glyptozaria* Iredale 108
  - *americana* **10**,108
  - *columaria* 108
  - *euglypta?* 108
- *Gomphopages* Gardner 60
- Gonzales County 9,11
- *gracillima, Syrnola* 118
- *gracilis,*
  - *Episiphon* **9**,45
  - *Metula* 70
  - *Tubiola* **9**,52
- *gradata, Arca* 26
- *grandis, Tropisurcula (Eodrillia)* **21**,96
- *gradus, Pseudometula* **15**,70
- *Granosolarium* Sacco 110
- *grayanus,*
  - *Crenomytilus* 28
  - *Mytilus* 28
- *Gregariella* Monterosato 29
  - *arcaforma* 29
  - *ridgei* **3**,29
- Guerava and Garcia (1972) 9

- *haliotoidea, Helix* 59
- *hamatoides, Hormomya* 29
- *harrisi,*
  - *Bullia altilis* **15**,74
  - *Chama* 34
  - *Dermatomya?* 36
  - *Laevibuccinum (Euryochetus?)* 83
  - *Rudiscala* 65
  - *Strepsidura* **17**,15,82
- *Hastula* H. and A. Adams 112
  - *benoisti* 112
  - *(Bulbihastula) ampulla* **22**,112
  - *(Bulbihastula) longifera* **22**,113
  - *milamensis* **22**,112
  - *houstonia* 112
  - *striata* 112
- Haszprunar (1988) 20

Heilprin (1891) 7
Helix haliotoidea 59
Hemifusus, remondii 63
hendersoni, Bathyarca 27
Heniastoma Cossmann 53
herbae, Trigonostoma (Ventrilia) **19**,88
Hesperiturris Gardner 98
  nodocarinatus 99
  nodocarinatus crassus **20**,98
  nodocarinatus enstrictus 99
Hesperiturris?
  monilis **20**,99
  monilis levae **20**,99
Hexaplex Perry 67
  eoa **14**,14,67
  (Hexaplex) silvaticus 67
  (Hexaplex) texanus 67
  (Hexaplex) vanuxemi 67
Hickman (1976) 18
hilli, Tritiaria 73
hindsii, Metula 69
Hippagus cardiiformis 45
hirando, Mytilus 30
Hodgkinson (1974) 20
Hodgkinson et al. (1992) 8
hodgkinsoni, Tenuimactra **6**,35,36
Hormomya hamatoides 29
houstonia,
  Calorhadia 23
  Hastula 112
Hullings (1955) 16
huppertzi, Pleurofusia? **20**,93
Hussey (1949) 9
Hussey (1951) 8
Hyotissa Stenzel 32
hyotis
  Mytilu 32
  offemanae **4**,15,324
hystrix, Pleurotoma 104

imbricata, Surculoma (Volutapex) **20**,91
infans, Turritella 50
intacta, Raphitoma (Microsurcula) 105
inurata, Mazzalina 78
irregularis, Admetula **19**,88
isocardioides, Crenella 29
iugum, Mathilda (Fimbriatella) **10**,107
iuventae, Raphitoma (Microsurcula) **22**,105

Joe Taylor Branch
  composite section 12
  locality descriptions 14–16
jonesae, Trigonostoma (Ventrilia) **19**,89
junceum, Metula 70
Jupiteria Bellardi 22

kamiyai, Nausitora 42
Katherinella Tegland 40
kellogii, Retusa (Cylichnina) 115
Kennedy Bluff 14
kennedyanus, Clavilithes 79
Kleinacteon Vokes 117
koeneni,
  Bittium 49
  Fusus 92
  Pyramimitra (Petrafixa) 93
koureos, Galeodea (Mambrina) 60
Kymatox Stenzel and Krause 36

Laevibuccinum Conrad 83
  (Euryochetus?) harrisi 83
  lineatum **17**,14,83
laevis, Drillia 96
laevisculpta, Cylichnina 114
lamarcki, Volvaria 89
lapillus, Surculites **16**,78
larvata, Pyramidella (Longchaeus) 119
Latirus Montfort 76
  aurantiacus 76
  (Polygona) traceyi **16**,76
  (Polygona) vokesae 77
  sexcostatus 77
lazarus, Chama 33
leana, Anatina 43
Leda acala 23
Leanella Cossmann 66
Leda atakta 24
Leon County 9
leonensis, Pholadomya, cf **8**,43
Leptosurcula Casey 94
  carinata **20**,94
levae, Hesperiturris? *monilis* **20**,99
levesquei, Scalaria 65
Levifusus Conrad 79,82
  trabeatoides 81
Levifusus?
  serrae **18**,80
  spiniger 80
lima, Byssoarca 26
Limacina
  stenzeli 8
  taylori 11
limopsis,
  Volutilithes 85
  Volutocorbis 85
limulus, Streptochetus 74
lineata,
  Cypraeorbis 56
  Eocythara **21**,103
  Mitrella (Clinurella) nuttalli **14**,69
lineatum, Laevibuccinum **17**,14,83
linguinodifera milamensis, Claibornicardia **5**,35
lissa, Arca 27
Lithoconus Mörch 90
Litiopa Rang 48
  melanostoma 48
  texana **14**,48
Litorhadia Stewart 23
  milamensis **1**,24
  sp. 25
  undulata **2**,242
  valdefragilis **2**,24
Litorhadia? bastropensis 25
Little Stave Creek 9
littorea, Littorina 51
littoreus, Turbo 50
Littorina Férussac 50
  littorea 51
  monodonta 50
  subobesa 51

Littorina (Prosthenodon eofasciata) **9**,50
Locality Descriptions 11–16
loisae, Volvulella 114
London Clay Formation 11
longchaeus, Clavilithes 78
longifera, Hastula (Bulbihastula) **22**,113
longirostropis, Pleurotoma 93
longissimum, Bittium 49
lonsdali, Pleurotoma 96
lucasensis, Columbraria (Columbraria) 70
Lucina, subvexa 33
luteofasciata, Theodoxus (Vittoclithon) 47
Lutetia Deshayes 38
  parisiensis 38
  texana, cf. **7**,38
Lyrodobankia Moll 42
Lyrosurcula Casey 92
  elegans 92
  cf. *vaughani* **20**,92
Lythe (1949) 11

macula, Amaea (Scalina) **12**,64–65
magnifica, Scalarius 64
magnoumbilicata, Natica (Tella) 58
Mambrina Gardner 60
Mangonuia Mestayer 109
margaritosa, Coronia, cf. **20**,98
marmorata, Bulla 113
marmoreus, Conus 90
marquezensis,
  Caryocorbula **7**,40
  notocorbula **8**,41
marylandica, Euspira 58
Mathilda Semper 106
  (Echinimathilda) corona 107
  (Echinimathilda?) cribraea **10**,107
  (Fimbriatella) filogranata 108
  (Fimbriatella) iugum **9**,107
  (Mathilda) cf. *claibornensis* **9**,107
  (Mathilda) cf. *retisculpta aldrichi* **9**,106
  (Mathilda) ripleyana 108
mauricensis, Nucula (Nucula) 22
maverickensis, Bankia 42
Mazzalina Conrad 77
  conica **16**,77
  inurata 77
  plena 77
  pyrula 77
meekana, Architectonica (Granosolarium) 111
Melanella Bowdich 66
  dufresnii 66
  extremis, aff. **23**,67
  minutissima **23**,66
  notata, cf. **23**,66,67
melanella, Odostomia (Evalea) 120
Melania rufa 121
melanostoma, Litiopa 48
Mesalia Gray 50
  claibornensis 50
  sp. **11**,50
meta, Turbonilla (Ptycheulimella) **23**,120
Metula H. and A. Adams 69
  amosi 70
  brazosensis 70
  elongatoides **15**,69
  fastidiosa 70
  gabbi 70
  gracilis 70
  hindsii 69
  junceum 70
  metula 70
  sylvaerupis 69,70
metula, Metula 70
meyeri, Fusus 75
Michela Gardner 81
  trabeatoides carinata **17**,15,82
microcancellata, Pachecoa 28
Microdrillia Casey 101
  robustula, aff. **21**,101
  rostratula **21**,101
  sp. **21**,102
Microsurcula Casey 93,103,105
  nucleola 103,105
Milam County 9
milamensis,
  Litorhadia **1**,24
  Hastula (Hastula) **22**,112
  Tellina (Eurytellina?) **6**,37
  Tropisurcula (Tropisurcula) **21**,95
  Volvariella **19**,90
milligranum, Solarium 110
millepunctatus, Conus 90
millsapsi, Galeodea (Gomphopages?) 60
minutissima,
  Melanella **23**,66
  Volvulella 114
minutus, Alveinus **7**,38
mississippiensis,
  Buccinum 72
  Chama (Psilopus) 34
  Mitrella (Clinurella) 68
Mitra terebraeformis 92
Mitrella Risso 68
  alabamensis 69
  (Clinurella) bucciniformis 68
  (Clinurella) mississippiensis 68
  (Clinurella) nuttalli **14**,68
  (Clinurella) nuttalli lineata **14**,69
  marmin 68
Mnestia H. and A. Adams 113
  confusa **22**,113
  rotunda **22**,113,114
Moerella Fisher 37
moffitti, Natica (Carinacca) **12**,58
Moniliopsis Conrad 101
monilis, Hesperiturris? **20**,99
monodonta, Littorina 50
monroensis, Chama 34
Moore (1969) 20
mooreana, Tellina (Eurytellina) 37
moorei,
  Latirus 76
  Pleurotoma 94
Morphological terms 20
moveum, Sinum **13**,60
Mud Creek 11
multiclavus, Serpulorbis **11**,55
multilineatum, Antillophos **18**,73
multiplicatus, Terebrifusus **16**,77

Murex
  cataphractus 100
  chichoreum 67
  colus 75
  reticulatus 48
  tubercularis 63
Mya glycymeris 41
Mytilus Linnaeus 28
  edulis 28
  grayanus 28
  hirando 30
  hyotis 32
  sp. 29

nana, Pseudoliva 84
nassulum, (cirsotrema (Coroniscala) 64
Natica Scopoli 57
  (Carinacca) moffitti **12**,58
  (Carinacca) rasensis 58
  (Naticarius) brevisulcata **12**,57
  (Naticarius) reversa 58
  (Tella) magnoumbilicata 58
"Natica"
  gliberti 58
  "(Naticarius)" semilunata 58
Naticarius Duméril 57
Nausitora kamiyai 42
nautiloides, Tubiola 52
Nautilus
  aturi 123
  triangulithes 122
naviculae, Transovula (Oxycypraea) 56
necropolitana, Cerithiopsis (Cerithiopsis) 63
neglecta, Turbonilla cf. **23**,120
negra, Pinna 29
Neosimnia Fisher 55
  regulatoides 56
  scobina **13**,55
Nerita
  canrena 57
  fluviatalis 47
  vitellus 57
Neritina
  unidentata 47
  virginica 47
Newby Member 8
nexilis, Fusinus 76
nivea, Turbo 52
nitens, Odostomia (Doliella) 119
nocens, Conus (Lithoconus) **19**,90
nodocarinatus, Hesperiturris 99
nodosa, Tritiaria **15**,72
nonplicata, Bathytoma, cf. **20**,100
Norissia Bayle 52
notata,
  Mellanella, cf. **23**,66,67
  Retusa (Cylichnina) **22**,114
Notocorbula Iredale 41
  marquezensis **8**,41
  texana 41
  vivarcia 41
nucleoides,
  Distorsio (Personella) **15**,71
  Ficopsis **14**,63
nucleola, Microsurcula 105

Nucula Lamarck, 1799 21
  cochlear **1**,22
  concava 22
  (Nucula) mauricensis 22
  (Nucula) smithvillensis 22
Nuculana Link, 1807 22
Nuculana (Jupiteria)
  smirna 23
  turgeo **1**,22
Nuculana (Saccella)
  catasarca 23
  demissa **1**,23
nuttalli, Mitrella (Clinurella) **14**,68

obliquus, Eosolen 36
Odostomia Fleming 119
  (Doliella) nitens 119
  (Doliella?) ova **23**,119
  (Evalea) melanella 120
  spp. 120
offemanae, Hyotissa **4**,15,32
Old Copper Prospect 8,11
Omalaxis Deshayes 111
  singlei 111
onustus, Polinices (Pliconacca) **12**,59
opulenta, Turritella 108
ora, Trimalaxis **11**,112
orbicularis, Glycymeria 28
ornata, Trigonulina 45
Orthoyoldia Verril and Bush 25
  psammotaea vivianensis **2**,25
Ostrea
  crenulimarginata 32
  pleuronectes 31
ottonis, Falsifusus **16**,75
ouachitensis, Cadulus (Gadila) 47
ova, Odostomia (Doliella?) **23**,119
ovalis, Cochlodesma (Cochlodesma) **8**,43
Ovula sepelta 55
ovulum, Dentalium 46
ozarkana, Anodontia (Eophysema) 33

Pachecoa Harris 27
  cantonis 28
  concentrica **3**,27
  decisa 28
  microcancellata 28
Pachycythara Woodring 103
Paleoenvironment 17–21
palmerae, Dentalium (Antalis) **9**,46
Pallets 42
panamensis, Vitrinella 51
panones, Trigonostoma 88
Panopea Menard 41
  sp. **8**,41
Papillina Conrad 79
papyria, Tellina (Eurytellina) 37
parilis, Admetula 88
parsnaticoides, Solariorbis? **9**,15,53
parvetorbis, Clavilithes **17**,14,15,78
Parvisipho Cossmann 70,83
Pasithea 66
Patulaxis Dall 110
Pectin (Propeamusium) ceciliae 31
pectunculoides, Arca 27

pendeltonensis, Solen 36
penna, Belosaepia **23**,122
Penrose, (1889) 7
penrosei,
  Surculoma 92
  Trigonostoma 89
perexilis, Pyramidella (Cossmannica) **23**,118
pernula, Arca 22
Personella Conrad 71
perspectivus, Trochus 109
petalus, Bankia (Lyrodobankia) **8**,42
Petrafixa Cossmann 92
petropolitana, Pteria **4**,30
petropolitanus, Pitar (Calpitaria) 39
Phalium Link 62
  brevicostatum 62
  (Semicassis) caelatura 62
  (Semicassis) reklawensis **13**,14,62
pharcida, Calorhadia 23
Philine 116
  alabamensis 116
  (Megistostoma) dockeryi 116
  (Megistostoma) gabbianum 116
  sp. **22**,116
Pholadomya G. B. Sowerby 43
  candida 43
  leonensis, cf. **8**,43
Phos Montfort 72
pinguis, Gegania 106
Pinna nigra 29
pirum, Pyramidella (Syrnola) **23**,118
Pisanella Koenen 93
Pitar Romer 39
Pitar (Calpitaria)
  petropolitanus 39
  texacola 39
  turneri **7**,39
  sp. **7**,40
Pitar (Katherinella?)
  sp. A **7**,40
  sp. B **7**,40
  texitrina 40
  trigoniata bastropensis 40
planicosta, Venericardia 34
planetica, Turricula 91
planotecta, Cassidaria 60
planulatum, Umbraculum 121
planus, Tropisurcula (Eodrillia) **21**,96
Platycythara Woodring 103
Platyschides Henderson 47
plena, Mazzalina 77
Pleurofusia de Gregorio 93
  claibarena 94
  huppertzi, ? **20**,93
pleuronectes, Ostrea 31
Pleurotoma
  acutirostra 97
  beadata 94
  childreni 97
  cossmanni 101
  depygis 95
  (Drillia) caseyi 95
  hystrix 104
  longirostropis 93
  moorei 94
  nuperus 95
  tabulata 91
Pleurotoma? carinatum 102
"*Pleurotoma (Bela)*" *rebeccae* 105
Plicatula Lamarck 31
  creola 32
  filamentosa **23**,31
  pustula **4**,31
plicatula, Turbonilla 120
plicatus, Spondylus 31
plicatus, Turbo 119
Pliconacca Cossmann and Martin 59
plumbeum, Buccinum 84
Plummer (1933) 8
plummerae, Pseudomalaxis 109
plummeri,
  Amaurellina **12**,57
  Siphonalia cf. **17**,85
Polinices Montfort 58
  albus 58
  aratus 59
  (Pliconacca) onustus 59
  (Pliconacca) onustus reklawensis **12**,59
  trisulcata 59
politum Teinostoma 54
Polygona Schumacher 76
  fusiformis 76
polyphragma, Serpulorbis 55
Ponder and Warén (1988) 20
Portlandica Morch 23
Postalia Oppenheim 54
  americana **13**,54
  postaliensis 54
postaliensis, Postalia 54
Powell (1966) 18
Propeamusium de Gregorio 31
prorsum, Buccinum 83
Prosimnia Schilder 56
Prosthenodon Cossmann 50
Protosurcula Casey 96
  aurora, ? **21**,15,97
  gabbi 97
  tenuirostris 97
psammotaea, vivianensis, Orthoyoldia **2**,25
pseudohystrix, Raphitoma 105
Pseudoliva Swainson 84
  nana 84
  cf. *santander* **18**,15,84
  vetusta 84
Pseudomalaxis Fisher 108,111
  acuta, ? **10**,109
  plummerae 109
  reklawensis **10**,109
  rotella 109
  texana 109
  verrili 109
Pseudometula new genus 70
  gradus **15**,70
Pteria Scopoli 30
  petropolitana **4**,30
  sp 30
Pteropsis Conrad 36
Pterynotus Swainson 68

  (Pterynotus) stenzeli, cf. **14**,68
punctatum, Euryochetus **16**,83
punctatus, Acteon pomilis **22**,116
punicea, Tellina 37
Purdy (1964) 186
pustula, Plicatula **4**,31
puteatus, Semiacteon 117
Ptycheulimella Sacco 120
Pycnodonte (Pycnodonte) trigonalis 32
pyramidata, Tornatella 120
Pyramidella Lamarck 117
  clandestina 118
  (Cossmannica) filamentosa **23**,118
  (Cossmannica) perexilis **23**,118
  (Cossmannica) tundrae **23**,119
  (Cossmannica) tundrae zigguratum **23**,119
  (Longchaeus) larvata 119
  (Syrnola) pirum **23**,118
  (Ulfa) chavani 118
Pyramimitra Conrad 92
  (Petrafixa) eocenica **20**,92
  (Petrafixa) koeneni 93
  quadrilirata 93
  terebraeformis 93
Pyramis 66
Pyrgiscus Philippi 121
Pyrgocythara Woodring 103
pyrula, Mazzalina 77

quadricarinata, Turbo 106
quadrilirata, Pyramimitra 93
Queen City Formation 7

radiata, Tellina 36
Ranella 73
  showalteri 73
  tuomeyi 73
Raphitoma Bellardi 104
  (Microsurcula) bastropensis **22**,105
  (Microsurcula) georgei **22**,105
  (Microsurcula) iuventae **22**,105
  (Microsurcula) intacta 105
  (Microsurcula) nucleola 103
  pseudohystrix 105
rasensis, Natica (Carinacca) 58
rarispina, Voluta 86
rebeccae, "Pleurotoma (Bela)" 105
Reed's Creek 11
regulatoides, Neosimnia 56
Reklaw Formation
  fossils, previously known 7,8
  history 7
  Marquez Member 9,11
  Newby Member 9,11
  size of faunas 21
  Stratigraphy 6,9
  type locality 9
reklawensis,
  Ancilla (Olivula) staminea **19**,87
  Anodontia (Eophysema) **4**,33
  Architectonica (Stellaxis) **10**,15,109
  Barbatia (Cucullaearca) **2**,26
  Buccinanops ellipticum **15**,74
  Eosurcula moorei **20**,94
  Raphitoma (Microsurcula) georgei **22**,105
  Phalium (Semicassis) **13**,14,62
  Polinices (Pliconacca) onustus **12**,59
  Pseudomalaxis **10**,109
  Venericor densata **6**,34
  Volvulella **22**,114
remondii, Hemifusus 63
reticulata, Volvariella 90
reticulatus, Murex 48
Retusa Brown 114
  (Cylichnina) cf. *adamski* **22**,115
  (Cylichnina) gabbi 115
  (Cylichnina) kellogii 115
  (Cylichnina) notata **22**,114
  sylvaerupis 115
reversa, Natica (Carinacca) 58
Rhizorus Montfort 114
Ridge Creek, localities 11,12–14
ridgei,
  Bittium **10**,49,64
  Domenginella **20**,100
  Gregariella **3**,29
ringens,
  Auricula 115
  Bankia 43
Ringicula Deshayes 115
  trapaquara 115
  cf. *trapaquara* **22**,15
ripleyana, Mathilda (Mathilda) 108
Rissoina d'Orbigny 66
  (Leanella) cossmanni 66
Robertson County 9,11
robustula, Microdrillia, aff. **21**,101
Roemer, 1846 6
rostratula, Microdrillia **21**,101
rotella, Pseudomalaxis 109
rotulus, Solariorbis 53
rotunda, Mnestia **22**,113
Rudiscala de Boury 65,66
  harrisi 65
  sessilis 65
rufa, Melania 121
Rugatiscala de Boury 65,66
  cooperi **12**,65,66
  sp. **12**,66
Rusk County 9,15
Russell (1941) 47

Sabine River beds 8
sabinetownensis, Trigonostoma 88
Saccella Woodring, 1925 23
salebrosus, Barbatia (Acar) **2**,26
Sams (1991) 11
Sams and Gatskill, (1990) 7,9,11,20–21
santander, Pseudoliva, cf. **18**,15,84
Sassia, conradiana 73
satex, Verticordia (Trigonulina), cf. **8**,45
sauridens, Conus (Lithoconus) 90
Scala 64
Scalaria
  cerithiformis 65
  levesquei 65
Scalaris
  magnifica 64
  staminea 64
scalaris,

  - *Clavilithes* 79
  - *Columbella (Clinurella)* 68
- *Scalina* Conrad 64
  - *trapaquara* 108
- *scapina, Yoldia* 25
- *scobina, Neosimna* **13**,55
- *Scobinella* Conrad 100
- *scrobiculata, Architectonica* 110
- *scrobiculatum, Solarium* 110
- *Semiacteon* Cossmann 117
  - *puteatus* 117
  - *texanum* **22**,117
- *Semicassis* Morch 62
- *semilunata, "Natica" "(Naticarius)":* 58
- *semiplicata, Bullia* 74
- *sepelta, Ovula* 55
- *sepioidea, Belosaepia* 122
- *septemdentata, (Personella) Distorsio* 71
- *Serpulorbis* Sassi 55
  - *multiclavus* **11**,55
  - *polyphragma* 55
- *serrae, Levifusus?* **18**,80
- *sessilis, Rudiscala* 65
- *sexcostatus, Latirus* 77
- *shirleyi, Eosolen* **5**,36
- *showalteri, Ranella* 73
- *silvaticus, Hexaplex (Hexaplex)* 67
- *singleyi,*
  - *Amaurellina* 57
  - *Omalaxis* 111
- *Sinum* Röding 59
  - *arctatum* 59
  - *declive* 59
  - *fiski* 59
  - *moveum* **13**,60
  - *taylori* **13**,59
- *Siphonalia* A. Adams 84
  - cf. *plummeri* **17**,85
- *siphonata, Columbraria (Columbraria)* 70
- *smirna, Nuculana (Jupiteria)* 23
- Smith, F. E. (1962) 6
- Smith, L. (1959, 1962, 1965) 16
- *smithii,*
  - *Varicobela* 104
  - *Athleta petrosa* **18**,14,15,86
  - *Strombus* 104
- *smithvillensis, Nucula (Nucula)* 22
- *Solariella* Wood 52
- *Solariorbis* Conrad 52
  - *conicus* **9**,53
  - *discoides* **9**,52
  - *rotulus* 53
- *Solariorbis?, parsnaticoides* **9**,15,53
- *Solarium*
  - *alveatum* 109
  - *millegranum* 110
  - *scrobiculatum* 110
- *Solen*
  - *(Eosolen) lisbonensis abruptus* 36
  - *obliquus* 36
  - *pendeltonensis* 36
- *sotoensis, Verticordia (Trigonulina)* 45
- *sowerbyi, Dentalium* 45
- *sphericulus, Tornatella* 117
- *spiniger, Levifusus?* 80
- *spirata, Ampullaria* 57
- *Spirolaxis* Monterosato 111
- *Spirotropis* Sars 102
  - *(Antiplanes)* cf. *bulimoides* 102
  - *claibornica* **21**,102
  - *(Antiplanes) perversa fernadoensis* 102
- *Spondylus plicatus* 31
- *squamulum, Amusium (Propeamusium)* 31
- *staminea,*
  - *Amaea (Scalina)* 64
  - *Ancilla (Olivula)* 87
  - *Ancilla (Olivula), reklawensis* **19**,87
  - *Scalaris* 64
- Steiner (1992) 20
- *Stellaxis* Dall 109
- Stenzel (1950) 8
- Stenzel (1953) 8,15
- Stenzel et al. (1957) 7,20
- *stenzeli,*
  - *Limacina* 8
  - *Pterynotus (Pterynotus),* cf. **14**,68
  - *Volutocorbis* **18**,85
- Stevenson (1953) 9
- *Strepsidura* Swainson 82
  - *costata* 82
  - *harrisi* **17**,15,82
- *Streptochetus limulus* 74
- *striata, Hastula* 112
- *strigillata, Terebra* 112
- *stromboides, Buccinum* 87
- *Strombus*
  - *canalis* 54
  - *smithii* 104
- *Stylidium* Dall 49
- *subcoarcuatus, Cadulus (Polyschides)* **9**,47
- *subobesa, Littorina* 51
- *subvexa,*
  - *Anodontia (Eophysema)* 33
  - *Lucina* 33
- *sulcataria, Callista* 39
- *sulcatus, Modiolus* 29
- *Surcula gabbi* 96
- *Surculites* Conrad 78,93
  - *annosa* 78
  - *cabezi* 78
  - *lapillus* **16**,78
- *Surculoma* Casey 91,95
  - *calantica* 91
  - *penrosei* 92
  - *(Volutapex) imbricata* **20**,91
- *Sveltia* Jousseaume 89
  - *alveata* 89
- Swanson (1981) 11
- *Sycostoma* Cox 81
  - *americanae* 81
  - *pyrus bulbiformis* 81
  - *texana* **17**,81
- *sylvaerupis*
  - *Architectonica* 110
  - *Metula* 69
  - *Retusa (Cylichnina)* 115
- *Syrnola* A. Adams 118
  - *gracillima* 118

tabulata, Pleurotoma 91
Tahusyrinx Powell 80
Talahatta Formation 9
tallicheti, Tellina 38
taylorensis, Chama **5**,33
taylori,
  Coronia **19**,97
  Limacina 11
  Sinum **13**,59
Teinostoma H. and A. Adams 54
  politum 54
  texanum, cf. **9**,54
Tellina Linnaeus 36
  crassa 37
  (Eurytellina) mooreana 37
  (Eurytellina) papyria 37
  punicea 37
  radiata 36
  tallicheti 38
Tellina (Eurytellina?) milamensis **6**,37
Tenagogus (Agathires) texana 55
tenera, Cancellaria 88
Tenuimactra hodgkinsoni **6**,35
tenuirostris, Protosurcula 97
Terebra Bruguière 112
  (Myurella) basterot 112
  strigillata 112
terebra, Turbo 49
terebraeformis,
  Mitra 92
  Pyramimitra 93
Terebrifusus Conrad 77
  amoenus 73
  multiplicatus **16**,77
Teredo bipalmulata 42
tenera, Cancellaria 88
texalana, Claibornicardia coloradonis 35
texacola, Pitar (Calpitaria) 39
texana,
  Amaea (Foratiscala) **12**,65
  Eocythara **21**,103
  Eodrillia 96
  Gegania antiquata **10**,106
  Litiopa **14**,48
  Lutetia cf., **7**,38
  Notocorbula 41
  Pseudomalaxis 109
  Sycostoma **17**,81
  Tenagogus (Agathires) 55
texanopsis, Eodrillia 96
texanum,
  Semiacteon **22**,117
  Teinostoma, cf. **9**,54
texanus, Hexaplex (Hexaplex) 67
texitrina, Pitar (Katherinella?) 40
thalloides, Dentalium (Antalis) 46
Theodoxus Montfort 47
  apertus 47
  domicilium **9**,47
  (Vittoclithon) luteofasciata 47
Threemile Creek 11
Timber Belt beds 8
tomaculum, Umbraculum **23**,121
Tornatella
  pyramidata 120
  sphericulus 117
tornatilis, Voluta 116
tortiplica, Admetula 88
towncreekensis, Cypraeorbis 56
trabeatoides,
  carinata, Michela **17**,15
  Levifusus 81
trabeatus, Fusus 79
traceyi, Latirus (Polygona) **16**,76
Transovula (Oxycypraea) naviculae 56
trapaquara,
  Amaea (Scalina) 64
  Ringicula cf. **22**,15,115
trapaquara, Scalina 108
tresquatrum, Bittium **10**,48
triangulithes, Nautilus 122
tricarinata, Belosaepia 122
trigonella, Glycymeris 28
Trigonostoma Blainville 88
  gemmatum 88
  panones 88
  penrosei 89
  sabinetownensis 88
  (Ventrilia) elegantissima **19**,89
  (Ventrilia) herbae **19**,88
  (Ventrilia) jonesae **19**,89
trigonostoma, Delphinula 88
Trimalaxis new genus 111
  ora **11**,112
trigonalis, Pycnodonte (Pycnodonte) 32
Trigonulina d'Orbigny 45
  ornata 45
Trinacria (Pachecoa) cainea 27
trisulcata, Polinices 59
Tritiaria Conrad 72
  albirupina 73
  hilli 73
  nodosa **15**,72
  zacatensis 73
Trochus
  dolabratus 117
  perspectivus 109
Tropisurcula Casey 95
  caseyi 95
  (Eodrillia) grandis **21**,96
  (Eodrillia) planus **21**,95,96
  (Tropisurcula) milamensis **21**,95
Trowbridge (1923) 9
trumani, Arcopagia (Arcopagia) **6**,38

tubercularis, Murex 63
Tubiola A. Adams 52
  gracilis **9**,52
  nautiloides 52
tumens, Venus 39
tundrae, Pyramidella (Cossmannica) **23**,119
tuomeyi,
  Athleta 86
  Ranella 73
Turbo
  littoreus 50
  nivea 52
  quadricarinata 106

  plicatus 119
  terebra 49
Turbonilla Risso 120
  cf. *neglecta* **23**,120
  plicatula 120
  (Ptycheulimella) clinensis 120
  (Ptycheulimella) meta **23**,120
  (Pyrgiscus) agrestis 121
  (Pyrgiscus) sp. **23**,
turgeo, Nuculana (Jupiteria) **1**,22
Turner, F. E. 8
turneri,
  Aturia **23**,14,123
  Galeodea (Mambrina) **14**,14,15,61
  Pitar (Calpitaria) **7**,39
  Turritella **11**,11,49
Turricula Schumacher 91,102
  flammea 91
  planetica 91
  sp. **19**,91
Turridrupa Hedley 93
Turris claytonensis 100
Turriscala de Boury 66
  brevialis 50
  dumblei 50
  infans 50
  opulenta 108
  turneri 11,49
Turritella Lamarck 49
  brevialis 50
  dumblei 50
  infans 50
  turneri **11**,7,49,50

Umbraculum Schumacher 121
  planulatum 121
  tomaculum **23**,121
Umbrella chinensis 121
undulata, Litorhadia **2**,24
unidentata, Neritina 47
uxoripalmeri, Barbatia 26

valdefragilis, Litorhadia **2**,24
valenciennesii, Fusus 76
vanuxemi, Hexaplex (Hexaplex) 67
Varicobela Casey 104
  aldrichi 104
  filum **21**,104
  smithi 104
vaughani, Lyrosurcula cf. **20**,92
Venericardia planicosta 34
Venericor Stewart 34
  densata reklawensis **6**,34
Ventrilia Jousseaume 88
  ventrilia 88
ventrilia, Ventrilia 88
ventripotens, Cypraeorbis 56
Venus tumens 39
verili, Pseudomalaxis 109
Vertebrates 8,15
Verticordia J. de C. Sowerby 44
  eocenensis 44
Verticordia (Trigonulina)
  cf. *satex* **8**,45
  sotoensis 45
vetusta, Pseudoliva 84
vicaria, Notocorbula 41
virginica, Neritina 47
vitellus, Nerita 57
Vitrinella panamensis 51
vokesae, Latirus (Polygona) 77
Voluta
  ampla 87
  rarispina 85
  tornatilis 116
Volutapex new subgenus 91,102
Volutilithes limopsis 85
Volutocorbis Dall 85
  limopsis 85
  stenzeli **18**,11,85
Volvaria lamarcki 89
Volvariella Fisher 89
  milamensis **19**,90
Volvulella Newton 114
  conradiana 114
  loisae 114
  minutissima 114
  reklawensis **22**,114

wathaoensis, Ampullina 58
Wendland and Knebel (1929) 9

Yancey, T. 7

zacatensis, Tritiaria 73
zanclaea, Bifrontia 108
zigguratum, Pyramidella (Cossmannica) tundrae **23**,119
zinguli, Amusium (Propeamusium) **4**,31

Table 1. Composition of the Reklaw fauna from Joe Taylor Branch (TB) and Ridge Creek (RC), the relative abundance of each species (a = abundant c = common u = uncommon r = rare), and the inferred habitat of each species. See text (p. 10) for details and references.

Species	TB	RC	Habitat of closest living relatives
SCAPHOPODA			
Dentalium (Antalis) palmerae n. sp.	a	c	Bay and pass to abyssal
Fustiaria (Episiphon) aciculata n. sp.	c	a	Middle neritic to slope
Cadulus bisissura n. sp.	r	r	Middle neritic to slope
Cadulus (Polyschides) aff. *subcoarcuatus* (Gabb,1860)		r	Fathoms, middle neritic to slope
BIVALVIA			
Nucula cochlear n. sp.	c	c	Neritic
Nucula (Nucula) aff. *smithvillensis* Stenzel & Twining, 1957	r		Neritic
Nuculana (Jupiteria) turgea n. sp.	c	c	Beach to inner neritic
Nuculana (Saccella) demissa n. sp.		r	Beach to inner neritic
Litorhadia milamensis n. sp.	r		Neritic
Litorhadia undulata n. sp.	c	c	Neritic
Litorhadia valdefragilis n. sp.	r	c	Neritic
Litorhadia sp.	r		Neritic
Orthoyoldia psammotaea vivianensis (Harris,1919)	r	u	Neritic
Barbatia (Acar) salebrosus n. sp.	r	r	Inner to middle neritic
Barbatia (Cucullaearca) reklawensis n. sp.	r	u	Inner to middle neritic
Bathyarca clabornica n. sp.	r	r	Outer neritic to slope
Pachecoa (Pachecoa) concentrica n. sp.	u	r	Shallow inner neritic
Glycymeris sp.	r		Neritic
Mytilus (Crenomytilus) sp.		r	Intertidal, attached
Gregariella ridgei n. sp.		r	Inner neritic boring in coral
Atrina? sp.	r		Inner neritic, in sand and mud
Pteria (Pteria) cf. *petropolitana* Stenzel & Twining, 1957	u		Intertidal to middle neritic
Pteria sp.		r	Intertidal to middle neritic
Amusium (Propeamussium) zinguli n. sp.	r	u	Middle neritic, slope
Plicatula pustula n. sp.	c	c	Intertidal to middle neritic
Hyotissa offemanae n. sp.		r	Outer neritic
Anodontia (Eophysema) reklawensis n. sp.	u		Tidal channel to midle neritic
Anodontia sp.		r	Tidal channel to middle neritic
Chama taylorensis n. sp.	c	c	Outer neritic, cemented
Venericor densata reklawensis n. sp.	c	c	Shallow neritic
Clairbornicardia milamensis n. sp.	u	c	Shallow neritic
Clairbornicardia milamensis linguanodifera n. sp.	r		Shallow neritic
Tenuimactra hodgkinsoni n. gen. n. sp.	r	r	Middle to outer neritic
Eosolen snurlevi n. sp.	r		Intertidal to neritic
Tellina (Eurytellina?) milamensis n. sp.	r		Bay to slope
Arcopagia (Arcopagia) trumani Harris 1897	r		Neritic
Lutetia texana reklawensis n. sp.	c		Bay to inner neritic
Alveinus cf. *minutus* Conrad, 1865	r	r	Bay to inner neritic
Pitar (Calpitaria) turneri n. sp.		r	Bay to inner neritic
Pitar (Katherinella?) sp.		r	Bay to inner neritic
Caryocorbula marquezensis n. sp.	c		Middle to outer neritic
Notocorbula marquezensis n. sp.	a	a	Middle to outer neritic
Panopea (?) sp.	r	r	Intertidal to shallow neritic
Bankia (Xylodobankia) petalus n. sp.	r		Wood borer, pelagic
Pholadomya cf. *leonensis* Stenzel & Twining, 1957	r	r	Neritic?
Cochlodesma (Cochlodesma) ovalis n. sp.	r	r	Pass, neritic?
Cardiomya? fredsmithi n. sp.	r	r	Outer neritic to slope
Cardiomya? sp.	r	r	Outer neritic to slope
Verticordia (Trigonulina) cf. *satex* Gardner, 1927		r	Outer neritic to slope
GASTROPODA			
Theodoxus domicilium n. sp.	r		Fluvatile to intertidal
Litiopa texana n. sp.	c	c	Pelagic
Bittium (Bittium) tresquatrum n. sp.	a	u	Tidal flats to inner neritic
Bittium (Bittium) ridgei n. sp.		u	Middle to outer neritic
Turritella turneri Plummer, 1933		c	Tidal flats, lagoon, beach, to inner neritic
Littorina (Prosthenodon) eofasciata n. sp.		r	Intertidal to shallow neritic
Cyclostremiscus axacuus (Conrad,1833)	r	r	Intertidal to inner neritic
Tubiola gracilis n. sp.	r	r	Outer neritic?
Solariorbis discoides n. sp.	c	c	Intertidal to inner neritic
Solariorbis conicus n. sp.		c	Intertidal to inner neritic
Solariorbis? parsnaticoides n. sp.	u		Intertidal to inner neritic
Teinostoma cf. *texanum* Palmer,1937	r		Intertidal to inner neritic
Ectinochilus sp.		r	Pass to slope
Postalia americana n. sp.	r	r	Inner to middle neritic, parasitic?
Serpulorbis? multiclavus n. sp.		u	Low intertidal
Neosimnia scobina n. sp.	r	r	Shallow to inner neritic, also reef dweller
Cypraeorbis bulbus n. sp.	r	r	Shallow to inner neritic, also reef dweller
Amaurellina plummeri n. sp.		c	Middle neritic
Natica (Naticarius) brevisulcata n. sp.	c	c	Inner neritic, tidal channel
Natica (Carinacca) moffitti n. sp.	c	u	Inner neritic, tidal channel
Polinices (Pliconacca) onustus reklawensis n. subsp.	c	c	Pass to outer neritic
Sinum taylori n. sp.	c	c	Middle neritic
Sinum moveum n. sp.	u	c	Middle neritic
Galeodea (Mambinas) turneri Gardner,1939	r	u	Intertidal to middle neritic?
Phalium (Semicassis) reklawensis n. sp.	u	u	Middle neritic to outer neritic?
Ficopsis nucleoides n. sp.	c	a	Pass to slope
Cerithiopsis (Cerithiopsina) sp.		r	Bay to inner neritic
Amaea (Scalina) macula n. sp.	u	c	Outer neritic
Amaea (Foratiscala) texana n. sp.		r	Middle to outer neritic
Rugatiscala cooperi n. sp.	r		Middle to outer neritic
Rugatiscala? sp.	r		Middle to outer neritic
Melanella minutissima n. sp.	r		Inner to outer neritic
Melanella cf. *notata* (I. Lea,1833)	r	r	Inner to outer neritic
Hexaplex eoa n. sp.		r	Pass to middle neritic?
Pterynotus (Pterynotus) cf. *stenzeli* Vokes,1970		r	Pass to middle neritic?
Mitrella (Clinurella) nuttalli n. sp.	r	u	Middle bay to middle neritic
Mitrella (Clinurella) nuttalli lineata n. sp.	r	c	Middle bay to middle neritic
Metula elongatoides n. sp.		r	Inner neritic
Pseudometula gradus n. gen. n. sp.		c	Inner neritic
Distorsio nucleoides n. sp.	r	c	Beach to middle neritic
Colwellia bilineata n. sp.	r	a	Intertidal to inner neritic?
Colwellia sp.	r		Intertidal to inner neritic?
Tritiaria nodosa n. sp.	a	a	Intertidal to inner neritic?
Antillophos multilineatum n. sp.	r	r	Inner to outer neritic
Buccinanops ellipticum reklawensis n. subsp.	u		Intertidal to inner neritic?
Bullia altilis harrisi n. sp.	r		Intertidal to inner neritic?
Falsifusus ottonis (Aldrich,1886)	c	c	Inner to middle neritic?
Fusinus claibornica n. sp.	r	u	Low tide to outer neritic
Latirus (Polygona) traceyi n. sp.		r	Middle to outer neritic
Terebrifusus multiplicatus (H. C. Lea, 1841)		r	Middle to outer neritic
Mazzalina conica n. sp.	r		Intertidal to inner neritic?
Surculites lapillus n. sp.	r	r	Beach, bay, inner neritic?
Clavilithes parvetorbis n. sp.	c	u	Middle neritic?
Clavilithes? acus n. sp.	r		Inner to middle neritic
Levifusus? serrae n. sp.	r	u	Inner to outer neritic?
Cornulina minax dockeryi n. sp.	r	r	Intertidal, reef dweller?
Sycostoma texana n. sp.	r		Middle neritic
Strepsidura harrisi Givens and Garvie, 1993	u	r	Beach to inner neritic
Euryochetus punctatum n. sp.		r	Inner neritic
Laevibuccinum lineatum Heilprin,1881	r	a	Intertidal to inner neritic?
Michela trabeatoides carinata n. subsp.	u	u	Middle to outer neritic
Pseudoliva cf. *santander* Gardner,1945	c	r	Bay, intertidal, inner neritic?
Siphonalia cf. *plummeri* Palmer,1937	r		Middle to outer neritic
Volutocorbis stenzeli Plummer, 1933	c	a	Inner to middle neritic?
Athleta petrosus smithi Fisher & Rodda, 1964	a	a	Inner to outer neritic
Cryptochorda sp.	r		Inner neritic?
Ancilla (Olivula) staminea reklawensis n. subsp.	c	a	Beach, inner neritic
Admetula irregularis n. sp.		u	Middle neritic to slope?
Trigonostoma (Ventrilia) herbae n. sp.	c	c	Middle neritic to slope
Trigonostoma (Ventrilia) elegantissima n. sp.	r	r	Middle neritic to slope
Trigonostoma (Ventrilia) jonesae n. sp.	r		Middle neritic to slope
Volvariella milamemsis n. sp.	u		Beach, inner neritic
Conus (Lithoconus) nocens n. sp.	r		Intertidal to middle neritic
Turricula sp.	a		Outer neritic
Surculoma imbricata n. sp.	c	a	Middle to outer neritic
Lyrosurcula cf. *vaughani* (Harris, 1895)	r		Middle to outer neritic
Pyramimitra (Petrafixa) eocenica n. sp.	r	r	Middle to outer neritic
Pleurofusia? huppertzi (Harris, 1895)	a	a	Middle to outer neritic
Leptosurcula carinata n. sp.		r	Middle to outer neritic
Eosurcula moorei reklawensis n. sp.	c	a	Inner to outer neritic
Tropisurcula milamensis n. sp.	a	a	Inner to outer neritic?
Tropisurcula (Eodrillia) planus n. sp.	a	a	Inner to outer neritic
Tropisurcula (Eodrillia) grandis n. sp.		r	Inner to outer neritic
Protosurcula aurora n. sp.	a	a	Inner to outer neritic
Coronia taylori n. sp.	a	a	Middle to outer neritic
Coronia cf. *margaritosa* (Casey,1904)		r	Middle to outer neritic
Hesperiturris nodocarinatus crassus n. subsp.	a	a	Middle to outer neritic
Hesperiturris? monilis n. sp.	c	c	Middle to outer neritic
Hesperiturris? monilis levae n. sp.	r		Outer neritic to slope
Bathytoma cf. *nonplicata* Harris, 1937	r	c	Outer neritic to slope
Domingella ridgei n. sp.		r	Outer neritic?
Microdrillia rostratula Casey, 1903	c	c	Inner to middle neritic
Microdrillia aff. *robustula* Casey, 1903		u	Inner to middle neritic
Spirotropis claibornica n. sp.		r	Outer neritic to slope
Eocythara texanum n. gen. n. sp.	c	a	Middle to inner neritic
Eocythara lineata n. gen. n. sp.	r		Middle to inner neritic
[illegible] n. sp.		r	Middle to inner neritic
Raphitoma (Microsurcula) georgei reklawensis n. subsp.	r		Middle neritic to slope
Raphitoma (Microsurcula) bastropensis n. sp.		r	Middle neritic to slope
Raphitoma (Microsurcula) iuventae n. sp.	c		Middle neritic to slope
Gegania antiquata texana (Palmer,1937)	r		Inner to outer neritic
Mathilda cf. *retisculpta aldrichi* Palmer,1937	r	u	Inner to outer neritic
Mathilda cf. *claibornensis* Aldrich, 1887		r	Inner to outer neritic
Mathilda (Echinimathilda?) cribraea n. sp.	u	u	Inner to outer neritic
Mathilda (Fimbriatella) iugum n. sp.		r	Inner to outer neritic
Glyptozaria americanae n. sp.		r	Outer neritic
Pseudomalaxis reklawensis n. sp.	r	a	Middle to outer neritic
Pseudomalaxis acuta n. sp.	r		Middle to outer neritic
Architectonica (Stellaxis) reklawensis n. sp.	r	u	Inner to middle neritic
Architectonica (Patulaxsis?) fimbiaea n. sp.	r		Inner to middle neritic
Architectonica (Granosolarium) aldrichi caterva n. sp.	r	u	Inner to middle neritic
Architectonica (Granosolarium) geminicostata n. sp.	c	c	Inner to middle neritic
Trimalaxis ora n. gen. n. sp.		r	Inner to middle neritic
Hastula milamensis n. sp.	u	c	Beach to middle neritic
Hastula (Bulbihastula) ampulla n. subgen. n. sp.	c	a	Beach to middle neritic
Hastula (Bulbihastula) longifera n. subgen. n. sp.	u		Beach to middle neritic
[illegible] n. sp.	r	u	Inner to outer neritic
[illegible] n. sp.	r	c	Inner to outer neritic
[illegible] n. sp.	c	r	Middle to outer neritic
Retusa (Cylichnina) notata n. sp.		c	Intertidal, bay to outer neritic
Retusa (Cylichnina) cf. *adamski* Palmer,1937	r	r	Intertidal, bay to outer neritic
Ringicula cf. *trapaquara* Harris, 1895	r	c	Shallow to inner neritic
[illegible] sp.		r	Inner to outer neritic
Acteon pomilis punctatus I. Lea, 1833	r	c	Deep inner to outer neritic
Semiacteon texanum n. sp.	r	r	Inner to outer neritic
Pyramidella (Syrnola) pirum n. sp.	r	u	Beach to outer neritic
Pyramidella (Cossmannica) perexilis (Conrad,1865)	a	u	Beach to outer neritic
Pyramidella (Cossmannica) filamentosa n. sp.	c	r	Beach to outer neritic
Pyramidella (Cossmannica) tundrae n. sp.	c	c	Beach to outer neritic
Pyramidella (Cossmannica) tundrae zigguratum n. sp.		r	Beach to outer neritic
Odostomia (Doliella?) ova n. sp.		c	Bay to outer neritic
Odostomia spp.		r	Bay to outer neritic
Turbonilla cf. *neglecta* Meyer,1886	r		Bay to slope
Turbonilla (Ptycheulimella) meta n. sp.	c	u	Bay to slope
Turbonilla (Pyrgiscus) sp.	r		Bay to slope
Umbraculum tomaculum n. sp.	r		Inner to middle neritic
CEPHALOPODA			
[illegible] n. sp.	c	c	Pelagic or neritic to benthic
Angulithes ellioti Stenzel, 1940		r	Pelagic or neritic to benthic
Aturia cf. *turneri* Stenzel, 1940	r	r	Pelagic or neritic to benthic

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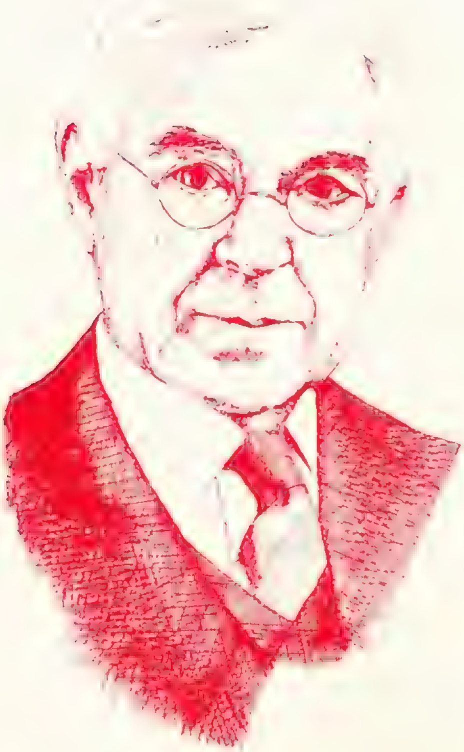

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